EXHIBIT 9

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June 27, 2018

<u>Via Certified Mail, Return Receipt Requested</u>
Aaron Herzog, President
Curtis International Ltd.
315 Attwell Drive
Etobicoke, Ontario M9W 5C1
Canada

Re: Curtis International Ltd.'s Infringement of Bandspeed, LLC's Patents

Dear Mr. Herzog:

This firm represents Bandspeed, LLC ("Bandspeed"). Bandspeed is the owner of the entire right, title, and interest in and to the following patents:

- United States Patent No. 7,027,418 ("the '418 Patent"), issued on April 11, 2006 for "Approach for Selecting Communications Channels Based on Performance."
- United States Patent No. 7,570,614 ("the '614 patent"), issued on August 4, 2009 for "Approach for Managing Communications Channels Based on Performance."
- United States Patent No. 7,477,624 ("the '624 Patent"), issued on January 13, 2009 for "Approach for Managing the Use of Communications Channels Based on Performance."
- United States Patent No. 7,903,608 ("the '608 Patent"), issued on March 8, 2011 for "Approach for Managing the Use of Communications Channels Based on Performance."
- United States Patent No. 8,542,643 ("the '643 Patent), issued on September 24, 2013 for "Approach for Managing the Use of Communications Channels Based on Performance."
- United States Patent No. 8,873,500 ("the '500 Patent), issued on October 28, 2014 for "Approach for Managing the Use of Communications Channels Based on Performance."
- United States Patent No. 9,379,769 ("the '769 Patent), issued on June 28, 2016 for "Approach for Managing the Use of Communications Channels Based on Performance."
- United States Patent No. 9,883,520 ("the '520 Patent), issued on January 30, 2018 for "Approach for Managing the Use of Communications Channels Based on Performance."

(collectively, the "Patents").

Bandspeed's Patents generally cover the implementation of adaptive frequency hopping, or "AFH," and associated functionality of Bluetooth Classic (BR/EDR) and Bluetooth Low Energy.

Curtis International Ltd., including Curtis International Ltd. C/O Lotus International Company, infringes the Patents by making, using, selling, importing, and/or offering for sale, the Bluetooth Classic Products identified in **Exhibit 1** ("Infringing Bluetooth Classic Products") and the Bluetooth Low Energy Products identified in **Exhibit 2** ("Infringing Bluetooth Low Energy Products").

<u>Bluetooth Adaptive Frequency Hopping</u>

Interference from a variety of sources, most notably wireless sources such as WiFi (802.11), can degrade the performance of communications channels used by Bluetooth devices. In general, AFH reduces the impact of interference on Bluetooth transmissions by directing the communications to "hop" from one channel to another according to a particular sequence that avoids channels potentially in use by other nearby networks and devices. AFH is therefore an approach for selecting sets of Bluetooth communications channels, and involves determining the performance of communications channels based on the results of testing and specified criteria. A device participating in a Bluetooth piconet generates data that identifies a selected set of channels and provides that data to other participants of the communications network. The participants then communicate over the set of channels.

Bluetooth Core Specification versions 1.2 and later refer to the Specification's channel classification, selection, and hopping protocol as "Adaptive Frequency Hopping," or "AFH." As shown in the attached representative claim charts, your products' implementation of the Specification provides compelling evidence of infringement.

<u>Bluetooth Classic (BR/EDR)</u>

Representative claim charts are attached as **Exhibits 3-4** and demonstrate how Curtis International Ltd.'s Infringing Bluetooth Classic Products (identified in **Exhibit 1**) infringe claims of Bandspeed's Patents. Curtis International Ltd. manufactures and sells Infringing Bluetooth Classic Products that are specifically designed to provide AFH and other functionalities in compliance with the Bluetooth Core Specification versions 1.2 and later in a manner that infringes the Patents. Curtis International Ltd. has certified that its Infringing Bluetooth Classic Products comply with the AFH functionality described in the Bluetooth Core Specification versions 1.2 and later.

<u>Bluetooth Low Energy</u>

Certain Bandspeed Patents[1] cover Bluetooth Low Energy ("LE") technology, described in versions 4.0 and later of the Bluetooth Core Specification. Representative claim charts are

[1] Curtis International Ltd.'s Infringing Low Energy Products infringe the following Bandspeed Patents: 7,027,418, 7,903,608, 8,542,643, 8,873,500, 9,379,769, 9,883,520.

attached as **Exhibits 5-6** and demonstrate how Curtis International Ltd.'s Infringing Bluetooth Low Energy Products (identified in **Exhibit 2**) infringe claims of Bandspeed's Patents. Curtis International Ltd. has certified that its Infringing Low Energy Products comply with the Low Energy functionality described in the Bluetooth Core Specification versions 4.0 and later.

Litigation and License History of the Bandspeed Patents

The lengthy litigation history of the Patents underscores the strength of the infringement case and the novelty of the inventions described by the claims. The first lawsuit, filed in August 2009 in the Western District of Texas, named Sony, Apple, Nintendo, Lego Systems, Parrot, and Scosche as defendants. In March 2010, CSR, a chipmaker, intervened in the first lawsuit.

The second lawsuit, filed in June 2010 in the Eastern District of Texas, named additional defendants, including Samsung, HTC, Motorola Mobility (Google), Research in Motion, Parrott, Toshiba, Garmin, Blackberry, Nintendo, Nokia, HP, Pantech, Lenovo, Dell, Sony, Belkin, Kyocera, LG, TomTom, Bluetooth SIG, NEC/Casio, Huawei, GN Netcom, Acer, Plantronics, etc.). The second lawsuit was transferred to the Western District of Texas and consolidated with the first lawsuit pending before Judge Lee Yeakel. Both the first and second lawsuit involved only two of the eight Patents: the '418 Patent and the '614 Patent.

The Court scheduled the case against CSR to proceed to trial first, effectively staying the case against the remaining defendants pending the outcome of the CSR case. The CSR case reached a relatively advanced stage, progressing through the Court's issuance of a claims construction order, completion of fact discovery, service of expert reports, and election of patent claims for trial. The case against CSR settled in 2012, and the case against the remaining defendants recommenced. The case remained active for about a year, and the last defendant, LG, settled weeks before a scheduled trial in May 2014.

The third lawsuit, filed in May 2014 in the Western District of Texas, named Bluetooth chipmakers Broadcom, Qualcomm, MediaTek, Marvell, ST Micro, and Texas Instruments as defendants and asserted six of the eight Patents: the '418 Patent, the '614 Patent, the '624 Patent, the '698 Patent, the '643 Patent, and the '500 Patent. *Inter Partes* Review (IPR) proceedings were initiated against four of the patents: the '624 Patent, the '643 Patent, the '608 Patent and the '500 Patent. The case against Marvell and MediaTek settled before the PTAB reached a final decision on the validity of these patents; the case against Qualcomm did not. In the PTAB's final written decision, the patents subject to IPR emerged with asserted claims intact, and Qualcomm was statutorily estopped from raising its full invalidity defense. For reference, the IPR proceedings that related to the chipmaker case are as follows:

IPR Number	Petitioner(s)	Patent Subject to IPR	Outcome
IPR2015-00314	Marvell and Mediatek	'624	Infringed Claims Survived
IPR2015-00315	Qualcomm	'624	Infringed Claims Survived
IPR2015-00316	Qualcomm	'624	Infringed Claims Survived
IPR2015-00531	Qualcomm	'643	Infringed Claims Survived
IPR2016-00620	Qualcomm	'500	Infringed Claims Survived

IPR2016-00623	Qualcomm	'500	Merged IPR2016-00620
IPR2015-00237	MediaTek	'608	Terminated
IPR2015-01577	Qualcomm	'624	Joined IPR2015-00314
IPR2015-01580	Qualcomm	'624	Joined IPR2015-00315
IPR2015-01581	Qualcomm	'624	Joined IPR2015-00316
IPR2015-01582	Qualcomm	'643	Joined IPR2015-00531

After the conclusion of the IPR process, the Qualcomm was case settled, and final judgment was entered by the Court in November 2017.

In total, one or more of the Bandspeed Patents has been litigated against each the following defendants:

1. Acer, Inc. and Acer America Corporation
2. Apple, Inc.
3. Belkin International, Inc. and Belkin, Inc.
4. Blackberry Ltd. and BlackBerry Corporation
5. BT SIG, Inc.
6. Cambridge Silicon Radio Limited
7. Dell, Inc.
8. Garmin International, Inc. and Garmin USA, Inc.
9. GN Netcom A/S and GN U.S., Inc.; GN Netcom, Inc.
10. Hewlett-Packard Company and Hewlett-Packard Development Company, L.P.
11. HTC Corporation and HTC America, Inc.
12. Huawei Technologies Co., Ltd.
13. Kyocera Communications, Inc. and Kyocera International, Inc.
14. Lenovo (United States), Inc.
15. LG
16. Motorola Solutions, Inc. and Motorola Mobility, Inc. (aka Motorola, Inc.) & Google
17. NEC CASIO Mobile Communication, Ltd.; Casio Computer Company, Ltd.; and Casio America, Inc.
18. Nintendo Co., Ltd.
19. Nokia Corporation
20. Pantech Co., Ltd. and Pantech Wireless, Inc.

21. Parrot, Inc.
22. Plantronics, Inc.
23. Samsung Electronics Co., Ltd.
24. Scosche Industries, Inc.
25. Sony Computer Entertainment America, Inc. and Sony Electronics, Inc.
26. TomTom International B.V. and TomTom, Inc.
27. Toshiba Corporation, Toshiba America Information Systems, Inc., and Toshiba America, Inc.
28. Broadcom Corporation
29. Marvell Semiconductor, Inc.
30. MediaTek USA, Inc.
31. Qualcomm Incorporated
32. STMicroelectronics N.V.
33. Texas Instruments Inc.

There are over 30 licensees of the Bandspeed Patents.

Infringement of the Bandspeed Patents

Curtis International Ltd. has been and currently is infringing, contributing to the infringement of, and/or inducing the infringement of all of the Bandspeed's Patents, by, among other things, making, using, selling, importing, and/or offering for sale, within the territorial boundaries of the United States, Infringing Bluetooth Classic Products and Infringing Bluetooth Low Energy Products that are covered by one or more claims of Bandspeed's Patents. Moreover, Curtis International Ltd. manufactures, provides, sells, offers for sale, imports, and/or distributes Infringing Bluetooth Classic Products and Infringing Bluetooth Low Energy Products and services; and/or induces others to make and use its Infringing Bluetooth Classic Products and Infringing Bluetooth Low Energy Products and services in an infringing manner; and/or contributes to the making and use of infringing products and services by others, including its customers, who directly infringe the Patents. *See* **Exhibits 1-6**.[2]

Bandspeed's charges of infringement against Curtis International Ltd. are not limited to the exemplary products and claims specifically identified in this letter. Rather, Bandspeed's infringement allegations include all of your products that operate in a reasonably similar manner (including all products that are representative of a qualified design approved by the Bluetooth SIG) for purposes of infringement of the Patents as the Infringing Bluetooth Classic Products and Infringing Bluetooth Low Energy Products.

It is Bandspeed's hope that the patent infringement controversy concerning Curtis

[2] Bandspeed accuses of infringement all products that operate in a reasonably similar manner.

International Ltd.'s products can be resolved through good faith negotiations and, ultimately, a license. In this regard, Bandspeed is willing to discuss with you the terms of a license agreement with respect to the Bandspeed Patents.

Please feel free to contact me at 512.539.2625 or gdonahue@dinovoprice.com if you would like to engage in licensing discussions or if you have any questions. We look forward to receiving your response.

Sincerely,

DINOVO PRICE LLP

By:______________________________

Enclosures

Exhibit 1. List of Curtis International Ltd.'s Bluetooth Classic Products known to Bandspeed.

Exhibit 2. List of Curtis International Ltd.'s Bluetooth Low Energy Products known to Bandspeed.

Exhibit 3. Representative claim chart for U.S. Patent 7,027,418 demonstrating infringement by Curtis International Ltd.'s Bluetooth Classic Products listed in Exhibit 1.

Exhibit 4. Representative claim chart for U.S. Patent 9,883,520 demonstrating infringement by Curtis International Ltd.'s Bluetooth Classic Products listed in Exhibit 1.

Exhibit 5. Representative claim chart for U.S. Patent 7,027,418 demonstrating infringement by Curtis International Ltd.'s Bluetooth Low Energy Products listed in Exhibit 2.

Exhibit 6. Representative claim chart for U.S. Patent 9,883,520 demonstrating infringement by Curtis International Ltd.'s Bluetooth Low Energy Products listed in Exhibit 2.

Exhibit 1. **List of Curtis International Ltd.'s Bluetooth Classic Products known to Bandspeed**

Bluetooth Classic Products	Bluetooth Declaration ID	Product Listing Category	Model	Publish Date
	End Product Listing (EPL)	Audio and Visual	SRCD232BT / PRCD232BT	2014-01-29
	End Product Listing (EPL)	Audio and Visual	SCR1232BT / PCR1232BT	2014-01-29
	End Product Listing (EPL)	Unique Products	PLT7904GBT / PLT7777GBT / PLT7602GBT / PLT7894GBT / PLT7802GBT / PLT8894GBT / PLT8235GBT / PLT8802GBT / PLT9894GBT / PLT9602GBT / PLT1094GBT / PLT1066GBT / PLT1025GBT / PLT1302GBT	2014-01-30
	End Product Listing (EPL)	Audio and Visual	SRCD635BT / PRCD635BT	2014-01-24
	End Product Listing (EPL)	Audio and Visual	SP9414 / PSP9414	2014-01-27
	End Product Listing (EPL)	Audio and Visual	SRCD684BT / PRCD684BT	2014-01-29
	End Product Listing (EPL)	Audio and Visual	SRCD262BT / PRCD262BT	2014-01-29
	End Product Listing (EPL)	Audio and Visual	SRCD1079BT / PRCD1079BT	2014-01-29
	End Product Listing (EPL)	Audio and Visual	SRCD7842BT / PRCD7842BT	2014-01-30
	End Product Listing (EPL)	Audio and Visual	SRCD645BT / PRCD645BT	2014-01-30
	End Product Listing (EPL)	Audio and Visual	SRCD267BT / PRCD267BT	2014-01-30
	End Product Listing	Audio and Visual	SRCD266BT / PRCD266BT	2014-01-30

	(EPL)			
	End Product Listing (EPL)	Audio and Visual	SP232 / PSP232	2014-01-29
	End Product Listing (EPL)	Audio and Visual	SP316 / SP316G / PSP316 / PSP316G	2014-01-29
	End Product Listing (EPL)	Audio and Visual	SP303 / PSP303	2014-01-27
	End Product Listing (EPL)	Audio and Visual	SP009 / PSP009	2014-01-29
	End Product Listing (EPL)	Audio and Visual	SP228 PSP228 SP229 PSP229 SP230 PSP230 SP231 PSP231 SP232 PSP232 SP233 PSP233 SP234 PSP234 SP235 PSP235	2014-01-31
	End Product Listing (EPL)	Audio and Visual	SP614 / PSP614	2014-01-27
	End Product Listing (EPL)	Audio and Visual	SP259 / PSP259	2014-01-27
	End Product Listing (EPL)	Audio and Visual	SBT236 / PBT236	2014-01-27
	End Product Listing (EPL)	Audio and Visual	SBT214 / SBT214A / PBT214 / PBT214A	2014-01-27
	End Product Listing (EPL)	Audio and Visual	SBT122 / PBT122	2014-01-27
	End Product Listing (EPL)	Audio and Visual	SBT228 / PBT228	2014-01-27
	End Product Listing (EPL)	Mobile Phone Accessory	SBTW210 / PBTW210 / SBTW211 / PBTW211 / SBTW212 / PBTW212	2014-01-29
	End Product Listing (EPL)	Audio and Visual	SBT311 PBT311 SBT312 PBT312 SBT313 PBT313 SBT314 PBT314 SBT315 PBT315 SBT316 PBT316 SBT317 PBT317 SBT318	2014-01-31

			PBT318 SBT319 PBT319 SBT320 PBT320 SBT321 PBT321 SBT322 PBT322 SBT323 PBT323 SBT324 PBT324 SBT325 PBT325	
	End Product Listing (EPL)	Audio and Visual	SBT122 SBT215 PBT122 PBT215 SBT123 SBT216 PBT123 PBT216 SBT124 SBT217 PBT124 PBT217 SBT125 SBT218 PBT125 PBT218 SBT126 SBT219 PBT126 PBT219 SBT127 SBT220 PBT127 PBT220 SBT128 SBT221 PBT128 PBT221 SBT129 SBT222 PBT129 PBT222 SBT130 SBT223 PBT130 PBT223 SBT1	2014-01-31
	End Product Listing (EPL)	Audio and Visual	SHTIB8418 / PHTIB8418	2014-01-27
	End Product Listing (EPL)	Audio and Visual	SB405 / PSB405	2014-01-27
	End Product Listing (EPL)	Audio and Visual	PSB393 / PSB373 / PSB323 / SB393 / SB373 / SB323	2014-01-27
	End Product Listing (EPL)	Audio and Visual	PSB3913 / PSB3713 / PSB3213 / SB3913 / SB3713 / SB3213 / PSB3913-SW / PSB3713-SW / PSB3213-SW / SB3913-SW / SB3713-SW / SB3213-SW	2014-01-27
	End Product Listing (EPL)	Audio and Visual	SP297 / PSP297	2014-01-27
	End Product Listing	Audio and Visual	SP386 / SP386G / SP288 / SP288G /	2014-01-27

	(EPL)		SP264 / SP264G / SP289 / SP265 / PSP386 / PSP386G / PSP288 / PSP288G / PSP264 / PSP264G / PSP289 / PSP265	
	End Product Listing (EPL)	Audio and Visual	SP317 / PSP317	2014-01-27
	End Product Listing (EPL)	Audio and Visual	SP245 / PSP245	2014-01-27
	End Product Listing (EPL)	Audio and Visual	SP262 / PSP262	2014-01-27
	End Product Listing (EPL)	Audio and Visual	SP277 / PSP277	2014-01-27
	End Product Listing (EPL)	Audio and Visual	SCR1996 / PCR1996	2014-01-27
	End Product Listing (EPL)	Audio and Visual	SP309 / PSP309	2014-01-27
	End Product Listing (EPL)	Audio and Visual	SRCD687BT / PRCD687BT	2014-01-29
	End Product Listing (EPL)	Audio and Visual	SP258 / PSP258	2014-01-29
	End Product Listing (EPL)	Audio and Visual	SP233 / PSP233	2014-01-29
	End Product Listing (EPL)	Audio and Visual	PSB379 / SB379	2014-01-30
	End Product Listing (EPL)	Audio and Visual	SP111 / PSP111	2014-01-30
	End Product Listing (EPL)	Audio and Visual	SP5686 / PSP5686	2014-01-27
	End Product Listing (EPL)	Audio and Visual	SHTIB1046BT / PHTIB1046BT	2014-01-30
	End Product Listing (EPL)	Audio and Visual	PHTIB1058BT / SHTIB1058BT	2014-01-30

	End Product Listing (EPL)	Audio and Visual	SP260 / SP260PL / PSP260 / PSP260PL / SP260B / SP260BPL / PSP260B / PSP260BPL / SP260D / SP260DPL / PSP260D / PSP260DPL	2014-01-24
	End Product Listing (EPL)	Audio and Visual	SBT233 / PBT233	2014-01-30
	End Product Listing (EPL)	Audio and Visual	SP269 / PSP269 / SP269B / PSP269B / SP269PL / PSP269PL	2014-01-29
	End Product Listing (EPL)	Audio and Visual	SPA026 / PSPA026	2014-01-29
	End Product Listing (EPL)	Audio and Visual	SPA025 / PSPA025	2014-01-29
	End Product Listing (EPL)	Audio and Visual	SPA027 / PSPA027	2014-01-29
	End Product Listing (EPL)	Audio and Visual	PSB3070 / SB3070	2014-01-30
	End Product Listing (EPL)	Audio and Visual	PSB3069	2014-01-30
	End Product Listing (EPL)	Audio and Visual	SRCD941BT / PRCD941BT	2014-01-30
	End Product Listing (EPL)	Audio and Visual	SRCD682BT / PRCD682BT	2014-01-30
	End Product Listing (EPL)	Audio and Visual	SRCD681BT / PRCD681BT	2014-01-30
	End Product Listing (EPL)	Audio and Visual	SRCD1218BT / PRCD1218BT	2014-01-30
	End Product Listing (EPL)	Audio and Visual	SRCD202BT / PRCD202BT	2014-01-30
	End Product Listing (EPL)	Audio and Visual	SPA021 / PSPA021	2014-01-30
	End Product Listing (EPL)	Audio and Visual	SPA023 / PSPA023	2014-01-30

	End Product Listing (EPL)	Audio and Visual	SP296 / PSP296	2014-01-30
	End Product Listing (EPL)	Audio and Visual	SP294/ PSP294	2014-01-30
	End Product Listing (EPL)	Audio and Visual	SCR1986 / PCR1986	2014-01-30
	End Product Listing (EPL)	Audio and Visual	SRCD1049BT / PRCD1049BT	2014-01-30
	End Product Listing (EPL)	Audio and Visual	SKCR2713 / PKCR2713	2014-01-31
	End Product Listing (EPL)	Audio and Visual	SRCD2731BT / PRCD2731BT SRCD2732BT / PRCD2732BT SRCD2733BT / PRCD2733BT SRCD2734BT / PRCD2734BT SRCD2735BT / PRCD2735BT SRCD2736BT / PRCD2736BT	2014-01-31
	End Product Listing (EPL)	Audio and Visual	SP648 / SP650/ SP651 / SP652 / SP653 / SP654 PSP648 / PSP650/ PSP651 / PSP652 / PSP653 / PSP654	2014-01-31
	End Product Listing (EPL)	Audio and Visual	SP649 / PSP649	2014-01-31
	End Product Listing (EPL)	Automotive	SCSD621 SCSD622 SCSD623 SCSD624 SCSD625 SCSD626 SCSD627 SCSD628 SCSD629 SCSD630	2014-01-31
	End Product Listing (EPL)	Automotive	SCSC014 SCSC015 SCSC016 SCSC017 SCSC018 SCSC019 SCSC020 SCSC021 SCSC022 SCSC023 SCSC024	2014-01-31
	End Product Listing (EPL)	Audio and Visual	SP701 PSP701 SP702 PSP702 SP703 PSP703 SP704 PSP704 SP705 PSP705 SP706 PSP706 SP707 PSP707 SP708 PSP708	2014-01-31

			SP709 PSP709 SP710 PSP710 SP711 PSP711 SP712 PSP712 SP713 PSP713 SP714 PSP714 SP715 PSP715 SP716 PSP716 SP717 PSP717 SP718 PSP718 SP719 PSP719 SP720 PSP	
	End Product Listing (EPL)	Audio and Visual	BLUETOOTH SPEAKER TOWER	2014-01-31
	End Product Listing (EPL)	Audio and Visual	SPA028 PSPA028 SPA029 PSPA029 SPA030 PSPA030 SPA031 PSPA031 SPA032 PSPA032 SPA033 PSPA033 SPA034 PSPA034 SPA035 PSPA035 SPA036 PSPA036 SPA037 PSPA037 SPA038 PSPA038 SPA039 PSPA039 SPA040 PSPA040 SPA041 PSPA041 SPA042 PSPA042	2014-01-31
	End Product Listing (EPL)	Audio and Visual	SRCD2401BT PRCD2401BT SRCD2402BT PRCD2402BT SRCD2403BT PRCD2403BT SRCD2404BT PRCD2404BT SRCD2405BT PRCD2405BT SRCD2406BT PRCD2406BT SRCD2407BT PRCD2407BT SRCD2408BT PRCD2408BT SRCD2409BT PRCD2409BT SRCD2410BT PRCD2410BT SRCD2411BT PRCD2411BT SRCD2412BT PRC	2014-01-31
	End Product Listing (EPL)	Audio and Visual	SP112 PSP112 SP113 PSP113 SP114 PSP114 SP115 PSP115 SP116 PSP116 SP117 PSP117	2014-01-31

			SP118 PSP118 SP119 PSP119 SP120 PSP120 SP121 PSP121 SP122 PSP122 SP123 PSP123 SP124 PSP124 SP125 PSP125 SP126 PSP126 SP127 PSP127 SP128 PSP128 SP129 PSP129 SP130 PSP130 SP131 PSP	
	End Product Listing (EPL)	Audio and Visual	PHTIB9418 / SHTIB9418	2014-01-27
	End Product Listing (EPL)	Audio and Visual	PHTIB8418 / SHTIB8418	2014-01-27
	End Product Listing (EPL)	Audio and Visual	SB405 / PSB405	2014-01-27
	End Product Listing (EPL)	Audio and Visual	PSB393 / PSB373 / PSB323 / SB393 / SB373 / SB323	2014-01-27
	End Product Listing (EPL)	Audio and Visual	PSB3913 / PSB3713 / PSB3213 / SB3913 / SB3713 / SB3213 / PSB3913-SW / PSB3713-SW / PSB3213-SW / SB3913-SW / SB3713-SW / SB3213-SW /	2014-01-27
	End Product Listing (EPL)	Audio and Visual	SP297 / PSP297	2014-01-27
	End Product Listing (EPL)	Audio and Visual	SP386 / SP386G / SP288 / SP288G / SP264 / SP264G / SP289 / SP265 / PSP386 / PSP386G / PSP288 / PSP288G / PSP264 / PSP264G / PSP289 / PSP265	2014-01-27
	End Product Listing (EPL)	Audio and Visual	SP317 / PSP317	2014-01-27
	End Product Listing (EPL)	Audio and Visual	SP245 / PSP245	2014-01-27
	End Product Listing (EPL)	Audio and Visual	SP262 / PSP262	2014-01-27

	End Product Listing (EPL)	Audio and Visual	SP277 / PSP277	2014-01-27
	End Product Listing (EPL)	Audio and Visual	SCR1996 / PCR1996	2014-01-27
	End Product Listing (EPL)	Audio and Visual	SP234 / PSP234	2014-01-27
	End Product Listing (EPL)	Audio and Visual	SP288 / PSP288	2014-01-29
	End Product Listing (EPL)	Audio and Visual	SP233 / PSP233	2014-01-29
	End Product Listing (EPL)	Audio and Visual	SP232 / PSP232	2014-01-29
	End Product Listing (EPL)	Audio and Visual	PSP302 / SP302-DG-SILVER/SP302/SP328/PSP328/SP328-B	2014-01-29
	End Product Listing (EPL)	Audio and Visual	SRCD7841BT / PRCD7841BT	2014-01-29
	End Product Listing (EPL)	Audio and Visual	SRCD114BT / PRCD114BT	2014-01-29
	End Product Listing (EPL)	Audio and Visual	PSP5687 / SP5687	2014-01-29
	End Product Listing (EPL)	Audio and Visual	SP237 / PSP237	2014-01-29
	End Product Listing (EPL)	Audio and Visual	SP008 / PSP008	2014-01-30
	End Product Listing (EPL)	Audio and Visual	sp006 / PSP006	2014-01-31
	End Product Listing (EPL)	Audio and Visual	SP007 / PSP007	2014-01-31
	End Product Listing (EPL)	Audio and Visual	SP102 / PSP102	2014-01-29
	End Product Listing	Audio and Visual	SP234 / PSP234	2014-01-27

	(EPL)			
	End Product Listing (EPL)	Audio and Visual	SP302 / PSP302	2014-01-29
	End Product Listing (EPL)	Audio and Visual	SRCD114BT / PRCD114BT	2014-01-29
	End Product Listing (EPL)	Audio and Visual	SP236 / PSP236	2014-01-29
	End Product Listing (EPL)	Audio and Visual	SP237 / PSP237	2014-01-29
	End Product Listing (EPL)	Audio and Visual	PHTIB9418 / SHTIB9418	2014-01-27
	End Product Listing (EPL)	Audio and Visual	SP236	2014-01-29
	End Product Listing (EPL)	Audio and Visual	SB406 / PSB406	2014-01-29
	End Product Listing (EPL)	Audio and Visual	PHTIB9418 / SHTIB9418	2014-01-27
	End Product Listing (EPL)	Audio and Visual	SHTIB8418 / PHTIB8418	2014-01-27
	End Product Listing (EPL)	Audio and Visual	SB405 / PSB405	2014-01-27
	End Product Listing (EPL)	Audio and Visual	PSB393 / PSB373 / PSB323 / SB393 / SB373 / SB323	2014-01-27
	End Product Listing (EPL)	Audio and Visual	PSB3913 / PSB3713 / PSB3213 / SB3913 / SB3713 / SB3213 / PSB3913-SW / PSB3713-SW / PSB3213-SW / SB3913-SW / SB3713-SW / SB3213-SW /	2014-01-27
	End Product Listing (EPL)	Audio and Visual	SP297 / PSP297	2014-01-27
	End Product Listing (EPL)	Audio and Visual	SP386 / SP386G / SP288 / SP288G / SP264 / SP264G / SP289 / SP265 /	2014-01-27

			PSP386 / PSP386G / PSP288 / PSP288G / PSP264 / PSP264G / PSP289 / PSP265	
	End Product Listing (EPL)	Audio and Visual	SP317 / PSP317	2014-01-27
	End Product Listing (EPL)	Audio and Visual	SP245 / PSP245	2014-01-27
	End Product Listing (EPL)	Audio and Visual	SP277 / PSP277	2014-01-27
	End Product Listing (EPL)	Audio and Visual	SCR1996 / PCR1996	2014-01-27
	End Product Listing (EPL)	Audio and Visual	SP263 / SP263G/ PSP263 / PSP263G	2014-01-30
	End Product Listing (EPL)	Audio and Visual	sb322 / sb324 / sb325 / sb326 / sb327 / sb328 / sb329 / sb330 / psb322 / psb324/ psb325 / psb326 / psb327 / psb328 / psb329 / psb330	2014-01-31
	End Product Listing (EPL)	Audio and Visual	SCR1997 / PCR1997	2014-01-31
	End Product Listing (EPL)	Audio and Visual	SB290 / SB390 / PSB290 / PSB390	2014-01-29
	End Product Listing (EPL)	Audio and Visual	PSB375W / SB375W	2014-01-30
	End Product Listing (EPL)	Audio and Visual	SB374W / SB376W / SB377W / SB378W/ SB379W PSB374W / PSB376W / PSB377W / PSB378W/ PSB379W	2014-01-31
	End Product Listing (EPL)	Audio and Visual	SB3201 SB3701 SB3901 SB3202 SB3702 SB3902 SB3203 SB3703 SB3903 SB3204 SB3704 SB3904 SB3205 SB3705 SB3905	2014-01-31

			SB3206 SB3706 SB3906 SB3207 SB3707 SB3907 SB3208 SB3708 SB3908 SB3209 SB3709 SB3909 SB3210 SB3710 SB3910 SB3211 SB3711 SB3911 SB3212 SB3712 SB3912 SB32	

Exhibit 2. **List of Curtis International Ltd.'s Bluetooth Low Energy Products known to Bandspeed**

Bluetooth Classic Products	Bluetooth Declaration ID	Product Listing Category	Model	Publish Date
	End Product Listing (EPL)	Unique Products	PLT7904GBT / PLT7777GBT / PLT7602GBT / PLT7894GBT / PLT7802GBT / PLT8894GBT / PLT8235GBT / PLT8802GBT / PLT9894GBT / PLT9602GBT / PLT1094GBT / PLT1066GBT / PLT1025GBT / PLT1302GBT	2014-01-30
	End Product Listing (EPL)	Audio and Visual	SB290 / SB390 / PSB290 /	2014-01-29

			PSB390	
	End Product Listing (EPL)	Audio and Visual	PSB375W / SB375W	2014-01-30
	End Product Listing (EPL)	Audio and Visual	SB374W / SB376W / SB377W / SB378W/ SB379W PSB374W / PSB376W / PSB377W / PSB378W/ PSB379W	2014-01-31
	End Product Listing (EPL)	Audio and Visual	SB3201 SB3701 SB3901 SB3202 SB3702 SB3902 SB3203 SB3703 SB3903 SB3204 SB3704 SB3904 SB3205 SB3705 SB390	2014-01-31

			5 SB3206 SB370 6 SB390 6 SB3207 SB370 7 SB390 7 SB3208 SB370 8 SB390 8 SB3209 SB370 9 SB390 9 SB3210 SB371 0 SB391 0 SB3211 SB371 1 SB391 1 SB3212 SB371 2 SB391 2 SB32	

Exhibit 3. **Representative claim chart demonstrating infringement by Curtis International Ltd.'s Bluetooth Classic Products.**

U.S. Patent No. 7,027,418 v. Curtis International Ltd.'s Bluetooth Classic Products

Overview

Plaintiff accuses the provision, use, and operation of Curtis International Ltd.'s ("Defendant") Bluetooth Classic Products of directly infringing U.S. Patent No. 7,027,418 (the "'418 Patent"). The term "Accused Devices" means Defendant's Bluetooth Classic Products and all associated interfaces, computer hardware, software and digital content, which includes but is not necessarily limited to the non-limiting example list of products included in *Exhibit 1*.

Plaintiff further accuses Defendant of indirectly infringing the '418 Patent through providing, authorizing and instructing regarding the Accused Devices to others, including its customers. Installing or activating the Accused Devices and the operation thereof directly infringe the asserted claims. Defendant intends to cause infringement by its customers and users. Defendant instructs users to use the Accused Devices in an infringing manner. Defendant enacts contractual protections requiring that the Accused Devices be used in a manner intended by Defendant. Defendant further instructs users to configure and operate the Accused Devices in an infringing manner. Defendant also provides support services for the Accused Devices, including providing instructions, guides, online materials and technical support.

The asserted claims include elements that are implemented, at least in part, by proprietary electronics and software in the Accused Devices. The precise source code, designs, data structures, processes, and algorithms used in them are held secret, at least in part, and are not publicly available in their entirety. An analysis of Defendant's documentation and/or source code may be necessary to fully and accurately describe all infringing features and functionality of the Accused Devices and, accordingly, Plaintiff reserves the right to supplement these contentions once such information is made available to Plaintiff. Furthermore, Plaintiff reserves the right to revise these contentions, including as discovery in the case progresses, in view of the Court's final claim construction in this action and in connection with the provision of its expert reports.

Claim 1	Infringement Contention
15[A]. A method for communicating with a participant in a communications arrangement, the method comprising the computer-implemented steps of:	The Accused Devices are wireless communications devices that certify compliance with the Bluetooth (“BT”) Core Specification (“CS”) Version 2.0+EDR (“CSv2.0+EDR”) or higher. CSv2.0+EDR is available for download at: https://www.bluetooth.org/DocMan/handlers/DownloadDoc.ashx?doc_id=40560. All Bluetooth Core Specifications are available at: https://www.bluetooth.com/specifications/bluetooth-core-specification. The Accused Devices (i.e., Defendant's Bluetooth products as identified by QDID in the attached appendix) may function in either master or slave roles in a Bluetooth piconet, as those terms are defined in CS. Qualified Device Listings (at links identified by QDID below) indicate: Link Manager: Table 26: Adaptive Frequency Hopping, Item 1: Support of AFH switch as master Link Manager: Table 26: Adaptive Frequency Hopping, Item 6: Support of Channel Classification During typical operation a physical radio channel is shared by a group of devices that are synchronized to a common clock and frequency hopping pattern. One device provides the synchronization reference and is known as the master. All other devices are known as slaves. A group of devices synchronized in this fashion form a piconet. This is the fundamental form of communication in the Bluetooth wireless technology. Source: CSv2.0+EDR, Vol. 1, p. 13.
15[B]. selecting, based on first performance data that indicates performance of a plurality of communications channels at a first time and at least a	The Accused Devices classify channels as unknown, bad, or good, based upon performance.

<table>
<tr>
<td>first performance criterion, a first set of two or more communications channels from the plurality of communications channels;</td>
<td>

RF channels are classified as being *unknown, bad or good*. These classifications are determined individually by the master and slaves based on local information (e.g. active or passive channel assessment methods or from the Host via HCI). Information received from other devices via LMP (e.g. an *AFH_channel_map* from a master or a channel classification report from a slave) shall not be included in a device's channel classification.

The three possible channel classifications shall be as defined in Table 8.6 on page 181.

<table>
<tr><th>Classification</th><th>Definition</th></tr>
<tr><td>unknown</td><td>A channel shall be classified as unknown if the channel assessment measurements are insufficient to reliably classify the channel, and the channel is not marked as bad in the most recent HCI Set_AFH_Channel_Classification.</td></tr>
<tr><td>bad</td><td>A channel may be classified as bad if an ACL or synchronous throughput failure measure associated with it has exceeded a threshold (defined by the particular channel assessment algorithm employed).
A channel may also be classified as bad if an interference-level measure associated with it, determining the interference level that the link poses upon other systems in the vicinity, has exceeded a threshold (defined by the particular channel assessment algorithm employed).
A channel shall be classified as bad when it is marked as bad in the most recent HCI Set_AFH_Channel_Classification command.</td></tr>
<tr><td>good</td><td>A channel shall be classified as good if it is not either unknown or bad.</td></tr>
</table>

Table 8.6: Channel classification descriptions

Source: CSv2.0+EDR, Vol. 3, p. 181.

</td>
</tr>
</table>

	A master with AFH enabled physical links shall determine an *AFH_channel_map* based on any combination of the following information: • Channel classification from local measurements (e.g. active or passive channel assessment in the Controller), if supported and enabled. The Host may enable or disable local measurements using the HCI *Write_AFH_Channel_Classification_Mode* command, defined in the HCI Functional Specification [Part E] Section 7.3.58 on page 537 if HCI is present. • Channel classification information from the Host using the HCI *Set_AFH_channel_classification* command, defined in the HCI Functional Specification [Part E] Section 7.3.58 on page 537 if HCI is present. Channels classified as *bad* in the most recent *AFH_Host_Channel_Classification* shall be marked as *unused* in the *AFH_channel_map*. • Channel classification reports received from slaves in *LMP_channel_classification* PDUs, defined in the LMP Specification [Part C] Section 4.1.5 on page 240. Source: CSv2.0+EDR, Vol. 3, p. 181. At least two channels are selected for use. The adapted piconet physical channel shall use at least N_{min} RF channels (where N_{min} is 20). Source: CSv2.0+EDR, Vol. 3, p. 75.
15[C]. generating first identification data that identifies the first set of two	Communication in a Bluetooth piconet is in the form of packets. In basic channel operation, packets are transmitted and received according to a pseudo-random sequence of hopping through 79 RF channels in the available frequency band.

<table>
<tr>
<td>or more communications channels;</td>
<td>

The Bluetooth system operates in the 2.4 GHz ISM band. This frequency band is 2400 - 2483.5 MHz.

Regulatory Range	RF Channels
2.400-2.4835 GHz	f=2402+k MHz, k=0,…,78

Table 2.1: Operating frequency bands

RF channels are spaced 1 MHz and are ordered in channel number k as shown in Table 2.1. In order to comply with out-of-band regulations in each country, a guard band is used at the lower and upper band edge.

Lower Guard Band	Upper Guard Band
2 MHz	3.5 MHz

Table 2.2: Guard Bands

Source: CSv2.0+EDR, Vol. 3, p. 29.

The physical channel used by the piconet is divided into time units known as slots. Packets are positioned in these slots for transmission.

The physical channel is sub-divided into time units known as slots. Data is transmitted between Bluetooth devices in packets, that are positioned in these slots. When circumstances permit, a number of consecutive slots may be allocated to a single packet. Frequency hopping takes place between the transmis-

Source: CSv2.0+EDR, Vol. 1, p. 13.

</td>
</tr>
</table>

	3.3.1.1 Overview The basic piconet channel is used for communication between connected devices during normal operation. *3.3.1.2 Characteristics* The basic piconet channel is characterized by a pseudo-random sequence hopping through the RF channels. The hopping sequence is unique for the piconet and is determined by the Bluetooth device address of the master. The phase in the hopping sequence is determined by the Bluetooth clock of the master. All Bluetooth devices participating in the piconet are time- and hop-synchronized to the channel. The channel is divided into time slots where each slot corresponds to an RF hop frequency. Consecutive hops correspond to different RF hop frequencies. The time slots are numbered according to the Bluetooth clock of the piconet master. Packets are transmitted by Bluetooth devices participating in the piconet aligned to start at a slot boundary. Each packet starts with the channel's access code, which is derived from the Bluetooth device address of the piconet. Source: CSv2.0+EDR, Vol. 1, p. 35. To mitigate or avoid the effects of interference on particular channels, the Accused Devices switch from basic channel operation (using all 79 channels) to adapted channel operation. In adapted channel operation, a subset of the 79 available channels in the frequency band are used for packet transmission.

	The adapted piconet channel differs from the basic piconet channel in two ways. First the frequencies on which the slaves transmit are the same as the preceding master transmit frequency. In other words the frequency is not recomputed between master and subsequent slave packets. The second way in which the adapted piconet channel differs from the basic piconet channel is that the adapted type can be based on fewer than the full 79 frequencies. A number of frequencies may be excluded from the hopping pattern by being marked as "unused". The remainder of the 79 frequencies are included. The two sequences are the same except that whenever the basic pseudo-random hopping sequence would have selected an unused frequency it is replaced with an alternative chosen from the used set. Source: CSv2.0+EDR, Vol. 1, p. 36. The adapted piconet physical channel shall use at least N_{min} RF channels (where N_{min} is 20). The adapted piconet physical channel uses the adapted channel hopping sequence described in Section 2.6 on page 82. Adapted piconet physical channels can be used for connected devices that have adaptive frequency hopping (AFH) enabled. There are two distinctions between basic and adapted piconet physical channels. The first is that the same channel mechanism that makes the slave frequency the same as the preceding master transmission. The second aspect is that the adapted piconet physical channel may be based on less than the full 79 frequencies of the basic piconet physical channel. Source: CSv2.0+EDR, Vol. 3, p. 75.

When the adapted channel hopping sequence is selected, the *AFH_channel_map* is an additional input to the selection box. The *AFH_channel_map* indicates which channels shall be *used* and which shall be *unused*. These terms are defined in Section 2.6.3 on page 89.

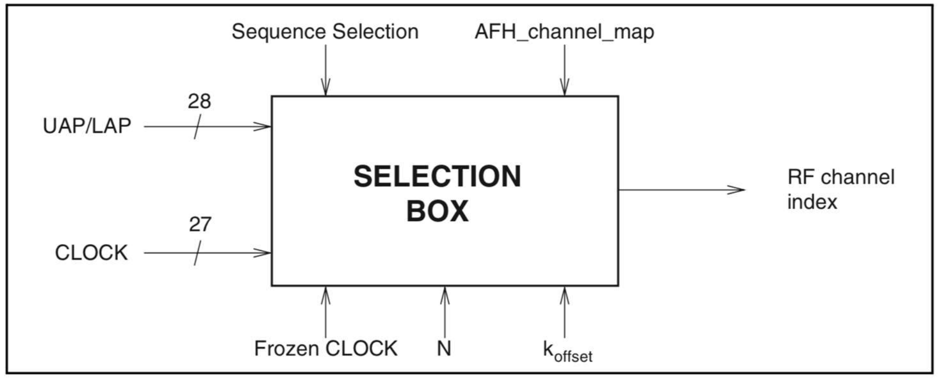


Figure 2.12: General block diagram of hop selection scheme.

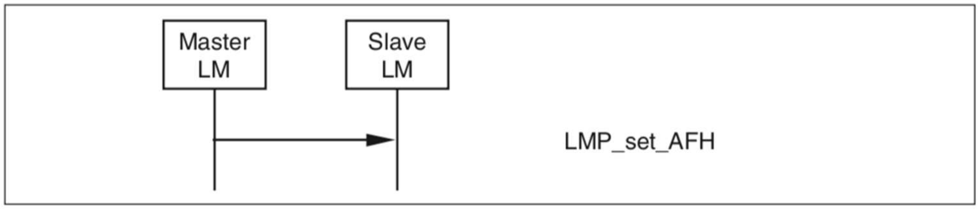
Source: CSv2.0+EDR, Vol. 3, p. 83.

The performance of each channel is evaluated to classify it as shown below.

	The three possible channel classifications shall be as defined in Table 8.6 on page 181. (see table below) Source: CSv2.0+EDR, Vol. 3, p. 181. To switch from basic to adapted channel operation or to update the channel map currently in use, the Accused Devices transmit packet data comprising a subset of channels to use for frequency hopping communication. For example, the LMP_set_AFH PDU (packet data unit) sent by master devices to slave device contains a parameter for AFH_channel_map. AFH_channel_map is identification data that identifies the first set of two or more communications channels to use for communication at a particular time.

Classification	Definition
unknown	A channel shall be classified as *unknown* if the channel assessment measurements are insufficient to reliably classify the channel, and the channel is not marked as *bad* in the most recent HCI *Set_AFH_Channel_Classification*.
bad	A channel may be classified as *bad* if an ACL or synchronous throughput failure measure associated with it has exceeded a threshold (defined by the particular channel assessment algorithm employed). A channel may also be classified as *bad* if an interference-level measure associated with it, determining the interference level that the link poses upon other systems in the vicinity, has exceeded a threshold (defined by the particular channel assessment algorithm employed). A channel shall be classified as *bad* when it is marked as *bad* in the most recent HCI *Set_AFH_Channel_Classification* command.
good	A channel shall be classified as *good* if it is not either *unknown* or *bad*.

Table 8.6: Channel classification descriptions

	4.1.4.1 Master enables AFH Prior to enabling AFH the master LM shall pause traffic on the ACL-U logical link (see Baseband Specification, Section 5.3.1, on page 108). The master shall then enable AFH on a physical link by sending the LMP_set_AFH PDU with AFH_mode set to AFH_enabled, the AFH_channel_map parameter containing the set of used and unused channels, and an AFH_instant. The LM shall not calculate the AFH instant until after traffic on the ACL-U logical link has been stopped. The master considers the physical link to be AFH_enabled once the baseband acknowledgement has been received and the AFH_instant has passed. Once the baseband acknowledgement has been received the master shall restart transmission on the ACL-U logical link.  *Sequence 5: Master Enables AFH.* Source: CSv2.0+EDR, Vol. 3, p. 238.

	4.1.4 Adaptive frequency hopping AFH is used to improve the performance of physical links in the presence of interference as well as reducing the interference caused by physical links on other devices in the ISM band. AFH shall only be used during the connection state. **M/O** | **PDU** | **Contents** O(35) Rx O(43) Tx | LMP_set_AFH | AFH_Instant, AFH_Mode, AFH_Channel_Map *Table 4.4: PDUs used for AFH* The LMP_set_AFH PDU contains three parameters: AFH_Instant, AFH_Mode, and AFH_Channel_Map. The parameter, AFH_Instant, specifies the instant at which the hopset switch will become effective. This is specified as a Bluetooth Clock value of the master's clock, that is available to both devices. The AFH instant is chosen by the master and shall be an even value at least 6*T_{poll} or 96 slots (whichever is greater) in the future, where T_{poll} is at least the longest poll interval for all AFH enabled physical links. The AFH_instant shall be within 12 hours of the current clock value. The parameter AFH_Mode, specifies whether AFH shall be enabled or disabled. The parameter AFH_Channel_Map, specifies the set of channels that shall be used if AFH is enabled. Source: CSv2.0+EDR, Vol. 3, p. 237.

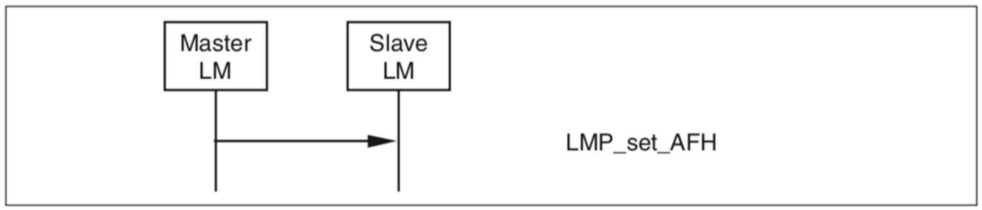
AFH_channel _classification	10	multiple bytes	-	This parameter contains 40 2-bit fields. The *n^th* (numbering from 0) such field defines the classification of channels *2n* and *2n+1*, other than the 39th field which just contains the classification of channel 78. Each field interpreted as an integer whose values indicate: 0 = unknown 1 = good 2 = reserved 3 = bad
AFH_channel _map	10	multiple bytes	-	If *AFH_mode* is *AFH_enabled*, this parameter contains 79 1-bit fields, otherwise the contents are reserved. The *n^th* (numbering from 0) such field (in the range 0 to 78) contains the value for channel *n*. Bit 79 is reserved (set to 0 when transmitted and ignored when received) The 1-bit field is interpreted as follows: 0: channel *n* is unused 1: channel *n* is used
AFH_instant	4	u_int32	slots	Bits 27:1 of the Bluetooth master clock value at the time of switching hop sequences. Must be even.

Source: CSv2.0+EDR, Vol. 3, p. 303.

	8.6.7 Hop sequence switching Hop sequence adaptation is controlled by the master and can be set to either *enabled* or *disabled*. Once enabled, hop sequence adaptation shall apply to all logical transports on a physical link. Once enabled, the master may periodically update the set of *used* and *unused* channels as well as disable hop sequence adaptation on a physical link. When a master has multiple physical links the state of each link is independent of all other physical links. When hop sequence adaptation is enabled, the *sequence selection* hop selection kernel input is set to *adapted channel hopping sequence* and the *AFH_channel_map* input is set to the appropriate set of *used* and *unused* channels. Additionally, the *same channel* mechanism shall be used. When hop sequence adaptation is enabled with all channels *used* this is known as AHS(79). When hop sequence adaptation is disabled, the *sequence selection* input of the hop selection kernel is set to *basic channel hopping sequence* (the *AFH_channel_map* input is unused in this case) and the *same channel* mechanism shall not be used. The hop sequence adaptation state shall be changed when the master sends the LMP_set_AFH PDU and a baseband acknowledgement is received. When the baseband acknowledgement is received prior to the hop sequence switch instant, *AFH_Instant*, (See Link Manager Protocol [Part C] Section 4.1.4 on page 237) the hop sequence proceeds as shown in Figure 8.9 on page 178. Source: CSv2.0+EDR, Vol. 3, p. 178.
15[D]. providing the first identification data to the participant;	The channel map identification data is provided from the master device to all slave devices in the piconet.

4.1.4.1 Master enables AFH

Prior to enabling AFH the master LM shall pause traffic on the ACL-U logical link (see Baseband Specification, Section 5.3.1, on page 108). The master shall then enable AFH on a physical link by sending the LMP_set_AFH PDU with AFH_mode set to AFH_enabled, the AFH_channel_map parameter containing the set of used and unused channels, and an AFH_instant. The LM shall not calculate the AFH instant until after traffic on the ACL-U logical link has been stopped. The master considers the physical link to be AFH_enabled once the baseband acknowledgement has been received and the AFH_instant has passed. Once the baseband acknowledgement has been received the master shall restart transmission on the ACL-U logical link.



Sequence 5: Master Enables AFH.

Source: CSv2.0+EDR, Vol. 3, p. 238.

	4.1.4 Adaptive frequency hopping AFH is used to improve the performance of physical links in the presence of interference as well as reducing the interference caused by physical links on other devices in the ISM band. AFH shall only be used during the connection state. (Table 4.4 below) *Table 4.4: PDUs used for AFH* The LMP_set_AFH PDU contains three parameters: AFH_Instant, AFH_Mode, and AFH_Channel_Map. The parameter, AFH_Instant, specifies the instant at which the hopset switch will become effective. This is specified as a Bluetooth Clock value of the master's clock, that is available to both devices. The AFH instant is chosen by the master and shall be an even value at least 6*T_{poll} or 96 slots (whichever is greater) in the future, where T_{poll} is at least the longest poll interval for all AFH enabled physical links. The AFH_instant shall be within 12 hours of the current clock value. The parameter AFH_Mode, specifies whether AFH shall be enabled or disabled. The parameter AFH_Channel_Map, speci-fies the set of channels that shall be used if AFH is enabled. Source: CSv2.0+EDR, Vol. 3, p. 237.

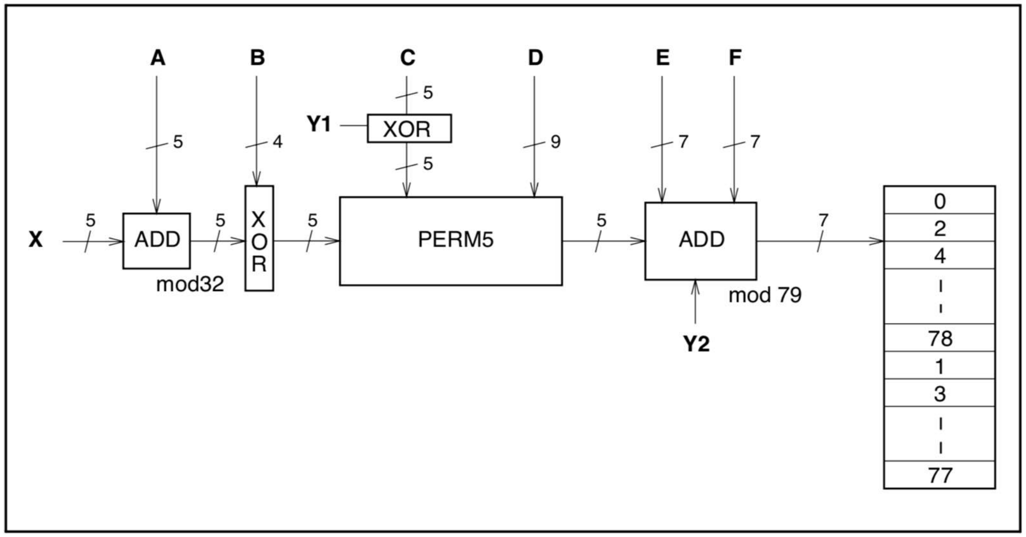
M/O	PDU	Contents
O(35) Rx O(43) Tx	LMP_set_AFH	AFH_Instant, AFH_Mode, AFH_Channel_Map

		AFH_channel _classification	10	multiple bytes	-	This parameter contains 40 2-bit fields. The n^{th} (numbering from 0) such field defines the classification of channels *2n* and *2n+1*, other than the 39[th] field which just contains the classification of channel 78. Each field interpreted as an integer whose values indicate: 0 = unknown 1 = good 2 = reserved 3 = bad
		AFH_channel _map	10	multiple bytes	-	If *AFH_mode* is *AFH_enabled*, this parameter contains 79 1-bit fields, otherwise the contents are reserved. The n^{th} (numbering from 0) such field (in the range 0 to 78) contains the value for channel *n*. Bit 79 is reserved (set to 0 when transmitted and ignored when received) The 1-bit field is interpreted as follows: 0: channel *n* is unused 1: channel *n* is used
		AFH_instant	4	u_int32	slots	Bits 27:1 of the Bluetooth master clock value at the time of switching hop sequences. Must be even.
	Source: CSv2.0+EDR, Vol. 3, p. 303.					

	8.6.7 Hop sequence switching Hop sequence adaptation is controlled by the master and can be set to either *enabled* or *disabled*. Once enabled, hop sequence adaptation shall apply to all logical transports on a physical link. Once enabled, the master may periodically update the set of *used* and *unused* channels as well as disable hop sequence adaptation on a physical link. When a master has multiple physical links the state of each link is independent of all other physical links. When hop sequence adaptation is enabled, the *sequence selection* hop selection kernel input is set to *adapted channel hopping sequence* and the *AFH_channel_map* input is set to the appropriate set of *used* and *unused* channels. Additionally, the *same channel* mechanism shall be used. When hop sequence adaptation is enabled with all channels *used* this is known as AHS(79). When hop sequence adaptation is disabled, the *sequence selection* input of the hop selection kernel is set to *basic channel hopping sequence* (the *AFH_channel_map* input is unused in this case) and the *same channel* mechanism shall not be used. The hop sequence adaptation state shall be changed when the master sends the LMP_set_AFH PDU and a baseband acknowledgement is received. When the baseband acknowledgement is received prior to the hop sequence switch instant, *AFH_Instant*, (See Link Manager Protocol [Part C] Section 4.1.4 on page 237) the hop sequence proceeds as shown in Figure 8.9 on page 178. Source: CSv2.0+EDR, Vol. 3, p. 178.
15[E]. communicating with the participant over the first set of two or more communications channels;	When hop sequence adaptation is enabled as described above, communication between devices proceeds using the channels identified in the channel map. or time slots. For each reception or transmission event an RF channel is selected by the hop selection kernel (see Section 2.6 on page 82).The maxi- Source: CSv2.0+EDR, Vol. 3, p. 70.

	8.6.7 Hop sequence switching Hop sequence adaptation is controlled by the master and can be set to either *enabled* or *disabled*. Once enabled, hop sequence adaptation shall apply to all logical transports on a physical link. Once enabled, the master may periodically update the set of *used* and *unused* channels as well as disable hop sequence adaptation on a physical link. When a master has multiple physical links the state of each link is independent of all other physical links. When hop sequence adaptation is enabled, the *sequence selection* hop selection kernel input is set to *adapted channel hopping sequence* and the *AFH_channel_map* input is set to the appropriate set of *used* and *unused* channels. Additionally, the *same channel* mechanism shall be used. When hop sequence adaptation is enabled with all channels *used* this is known as AHS(79). When hop sequence adaptation is disabled, the *sequence selection* input of the hop selection kernel is set to *basic channel hopping sequence* (the *AFH_channel_map* input is unused in this case) and the *same channel* mechanism shall not be used. The hop sequence adaptation state shall be changed when the master sends the LMP_set_AFH PDU and a baseband acknowledgement is received. When the baseband acknowledgement is received prior to the hop sequence switch instant, *AFH_Instant*, (See Link Manager Protocol [Part C] Section 4.1.4 on page 237) the hop sequence proceeds as shown in Figure 8.9 on page 178. Source: CSv2.0+EDR, Vol. 3, p. 178. When unused channels are selected as candidate channels by the hop selection kernel, they are remapped to used channels.

	2.6.3.1 Channel re-mapping function When the adapted hop selection kernel is selected, the basic hop selection kernel according to Figure 2.16 on page 86 is initially used to determine an RF channel. If this RF channel is *unused* according to the *AFH_channel_map*, the *unused* RF channel is re-mapped by the re-mapping function to one of the *used* RF channels. If the RF channel determined by the basic hop selection kernel is already in the set of *used* RF channels, no adjustment is made. The hop sequence of the (non-adapted) basic hop equals the sequence of the adapted selection kernel on all locations where *used* RF channels are generated by the basic hop. This property facilitates non-AFH slaves remaining synchronized while other slaves in the piconet are using the adapted hopping sequence. Source: CSv2.0+EDR, Vol. 3, p. 89.

	The basic hop selection kernel shall be as shown in Figure 2.16 on page 86 and is used for the page, page response, inquiry, inquiry response and basic channel hopping selection kernels. In these substates the AFH_channel_map input is unused. The adapted channel hopping selection kernel is described in Section 2.6.3 on page 89. The X input determines the phase in the 32-hop segment, whereas Y1 and Y2 selects between master-to-slave and slave-to-master. The inputs A to D determine the ordering within the segment, the inputs E and F determine the mapping onto the hop frequencies. The kernel addresses a register containing the RF channel indices. This list is ordered so that first all even RF channel indices are listed and then all odd hop frequencies. In this way, a 32-hop segment spans about 64 MHz.  *Figure 2.16: Block diagram of the basic hop selection kernel for the hop system.* The selection procedure consists of an addition, an XOR operation, a permutation operation, an addition, and finally a register selection. In the remainder of this chapter, the notation A_i is used for bit i of the BD_ADDR. Source: CSv2.0+EDR, Vol. 3, p. 86.

<table>
<tr>
<td>15[F]. wherein the plurality of communications channels correspond to a set of frequencies to be used based on a hopping sequence according to a frequency hopping protocol;</td>
<td>The RF channels used for transmitting and receiving in the piconet correspond to a set of frequencies according to a pseudo-random sequence of hopping through 79 RF channels in the available frequency band.

The Bluetooth system operates in the 2.4 GHz ISM band. This frequency band is 2400 - 2483.5 MHz.

<table>
<tr><th>Regulatory Range</th><th>RF Channels</th></tr>
<tr><td>2.400-2.4835 GHz</td><td>f=2402+k MHz, k=0,…,78</td></tr>
</table>
Table 2.1: Operating frequency bands

RF channels are spaced 1 MHz and are ordered in channel number k as shown in Table 2.1. In order to comply with out-of-band regulations in each country, a guard band is used at the lower and upper band edge.

<table>
<tr><th>Lower Guard Band</th><th>Upper Guard Band</th></tr>
<tr><td>2 MHz</td><td>3.5 MHz</td></tr>
</table>
Table 2.2: Guard Bands

Source: CSv2.0+EDR, Vol. 3, p. 29.</td>
</tr>
</table>

	3.3.1.1 Overview The basic piconet channel is used for communication between connected devices during normal operation. *3.3.1.2 Characteristics* The basic piconet channel is characterized by a pseudo-random sequence hopping through the RF channels. The hopping sequence is unique for the piconet and is determined by the Bluetooth device address of the master. The phase in the hopping sequence is determined by the Bluetooth clock of the master. All Bluetooth devices participating in the piconet are time- and hop-synchronized to the channel. The channel is divided into time slots where each slot corresponds to an RF hop frequency. Consecutive hops correspond to different RF hop frequencies. The time slots are numbered according to the Bluetooth clock of the piconet master. Packets are transmitted by Bluetooth devices participating in the piconet aligned to start at a slot boundary. Each packet starts with the channel's access code, which is derived from the Bluetooth device address of the piconet. Source: CSv2.0+EDR, Vol. 1, p. 35. The set of used channels may be adapted to be based on fewer than the full 79 frequencies to mitigate the effects of interference. The adapted piconet channel differs from the basic piconet channel in two ways. First the frequencies on which the slaves transmit are the same as the preceding master transmit frequency. In other words the frequency is not recomputed between master and subsequent slave packets. The second way in which the adapted piconet channel differs from the basic piconet channel is that the adapted type can be based on fewer than the full 79 frequencies. A number of frequencies may be excluded from the hopping pattern by being marked as "unused". The remainder of the 79 frequencies are included. The two sequences are the same except that whenever the basic pseudo-random hopping sequence would have selected an unused frequency it is replaced with an alternative chosen from the used set. Source: CSv2.0+EDR, Vol. 1, p. 36.

	The adapted piconet physical channel shall use at least N_{min} RF channels (where N_{min} is 20). The adapted piconet physical channel uses the adapted channel hopping sequence described in Section 2.6 on page 82. Adapted piconet physical channels can be used for connected devices that have adaptive frequency hopping (AFH) enabled. There are two distinctions between basic and adapted piconet physical channels. The first is that the same channel mechanism that makes the slave frequency the same as the preceding master transmission. The second aspect is that the adapted piconet physical channel may be based on less than the full 79 frequencies of the basic piconet physical channel. Source: CSv2.0+EDR, Vol. 3, p. 75.

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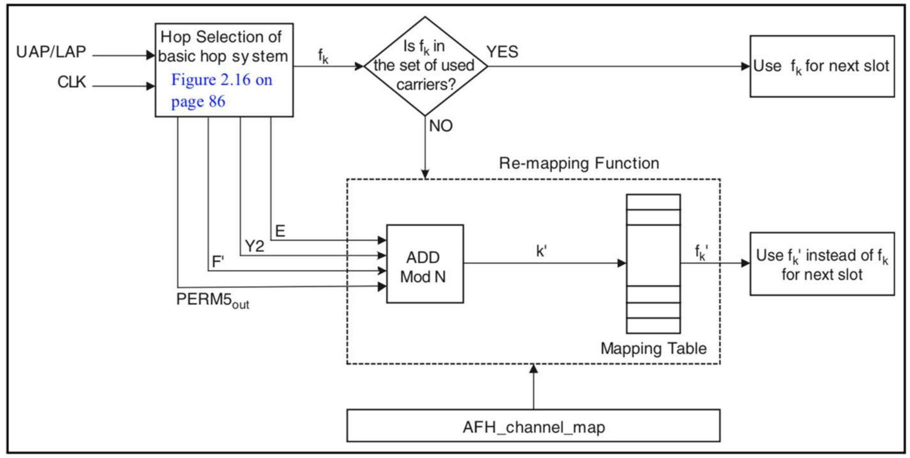

Figure 2.20: Block diagram of adaptive hop selection mechanism

When an unused RF channel is generated by the basic hop selection mechanism, it is re-mapped to the set of *used* RF channels as follows. A new index k' $\in$ {0, 1,..., N-1} is calculated using some of the parameters from the basic hop selection kernel:

$$k' = (PERM5_{out} + E + F' + Y2) \bmod N$$

where F' is defined in Table 2.2 on page 91. The index k' is then used to select the re-mapped channel from a mapping table that contains all of the even *used* RF channels in ascending order followed by all the odd *used* RF channels in ascending order (i.e., the mapping table of Figure 2.16 on page 86 with all the *unused* RF channels removed).

Source: CSv2.0+EDR, Vol. 3, p. 90.
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<td>**15[G].** wherein at each hop in the hopping sequence, only one communications channel is used for communications</td>
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For each transmission/reception event, a single channel is used for communication between participants.

or time slots. For each reception or transmission event an RF channel is selected by the hop selection kernel (see Section 2.6 on page 82).The maxi-

Source: CSv2.0+EDR, Vol. 3, p. 70.
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<td>between a pair of participants;</td>
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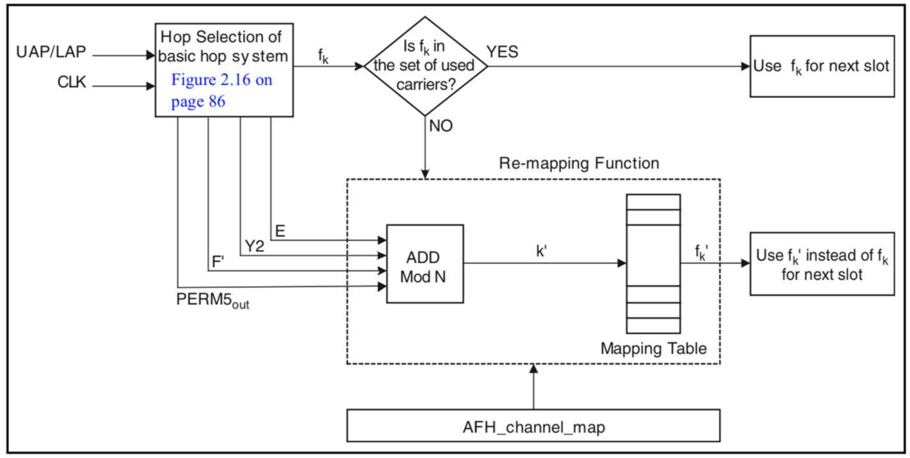

Figure 2.20: Block diagram of adaptive hop selection mechanism

When an unused RF channel is generated by the basic hop selection mechanism, it is re-mapped to the set of *used* RF channels as follows. A new index k' $\in$ {0, 1,..., N-1} is calculated using some of the parameters from the basic hop selection kernel:

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where F' is defined in Table 2.2 on page 91. The index k' is then used to select the re-mapped channel from a mapping table that contains all of the even *used* RF channels in ascending order followed by all the odd *used* RF channels in ascending order (i.e., the mapping table of Figure 2.16 on page 86 with all the *unused* RF channels removed).

Source: CSv2.0+EDR, Vol. 3, p. 90.

The RF frequency selected remains fixed for the duration of packet transmission.

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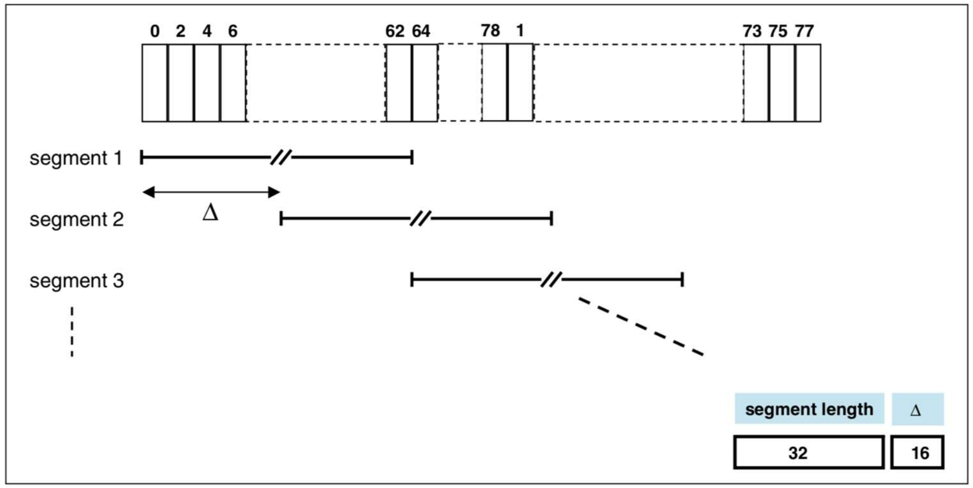
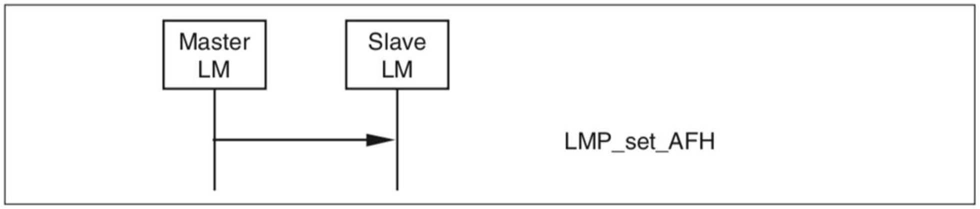
	 *Figure 2.13: Hop selection scheme in CONNECTION state.* The RF frequency shall remain fixed for the duration of the packet. The RF fre- Source: CSv2.0+EDR, Vol. 3, p. 84.
15[H]. wherein the first identification data is provided to the participant over one communications channel of the plurality of communications channels based on the hopping sequence according to the frequency hopping protocol;	The identification data such as that in the LMP_set_AFH PDU is transmitted to slave devices over a single channel based on the same hopping sequence according to the frequency hopping protocol as other communication with devices in the piconet.

	4.1.4.1 Master enables AFH Prior to enabling AFH the master LM shall pause traffic on the ACL-U logical link (see Baseband Specification, Section 5.3.1, on page 108). The master shall then enable AFH on a physical link by sending the LMP_set_AFH PDU with AFH_mode set to AFH_enabled, the AFH_channel_map parameter containing the set of used and unused channels, and an AFH_instant. The LM shall not calculate the AFH instant until after traffic on the ACL-U logical link has been stopped. The master considers the physical link to be AFH_enabled once the baseband acknowledgement has been received and the AFH_instant has passed. Once the baseband acknowledgement has been received the master shall restart transmission on the ACL-U logical link.  *Sequence 5: Master Enables AFH.* Source: CSv2.0+EDR, Vol. 3, p. 238.

	4.1.4 Adaptive frequency hopping AFH is used to improve the performance of physical links in the presence of interference as well as reducing the interference caused by physical links on other devices in the ISM band. AFH shall only be used during the connection state. **M/O** | **PDU** | **Contents** O(35) Rx O(43) Tx | LMP_set_AFH | AFH_Instant, AFH_Mode, AFH_Channel_Map *Table 4.4: PDUs used for AFH* The LMP_set_AFH PDU contains three parameters: AFH_Instant, AFH_Mode, and AFH_Channel_Map. The parameter, AFH_Instant, specifies the instant at which the hopset switch will become effective. This is specified as a Bluetooth Clock value of the master's clock, that is available to both devices. The AFH instant is chosen by the master and shall be an even value at least 6*T_{poll} or 96 slots (whichever is greater) in the future, where T_{poll} is at least the longest poll interval for all AFH enabled physical links. The AFH_instant shall be within 12 hours of the current clock value. The parameter AFH_Mode, specifies whether AFH shall be enabled or disabled. The parameter AFH_Channel_Map, specifies the set of channels that shall be used if AFH is enabled. Source: CSv2.0+EDR, Vol. 3, p. 237. LMP messages are transmitted in a single packet, over a single time slot and channel. No LMP message shall exceed the maximum payload length of a single DM1 packet i.e. 17 bytes in length (Baseband Specification, Section 6.5.4.1, on page 126). Source: CSv2.0+EDR, Vol. 3, p. 224.

	The DM1 packet carries data information only. The payload has between 1 and 18 information bytes (including the 1-byte payload header) plus a 16-bit CRC code. The DM1 packet occupies a single time slot. The information plus CRC bits are coded with a rate 2/3 FEC. The payload header in the DM1 packet is 1 byte long, see Figure 6.12 on page 130. The length indicator in the payload header specifies the number of user bytes (excluding payload header and the CRC code). Source: CSv2.0+EDR, Vol. 3, p. 126.
15[I]. determining, based on second performance data that indicates performance of the first set of two or more communications channels at a second time that is later than the first time, a number of communications channels from the first set of two or more communications channels that satisfy at least a second performance criterion; and	The Accused Devices monitor and classify channels on an ongoing basis and/or according to a schedule.

	RF channels are classified as being *unknown, bad or good*. These classifications are determined individually by the master and slaves based on local information (e.g. active or passive channel assessment methods or from the Host via HCI). Information received from other devices via LMP (e.g. an *AFH_channel_map* from a master or a channel classification report from a slave) shall not be included in a device's channel classification. The three possible channel classifications shall be as defined in Table 8.6 on page 181. (see table below) Source: CSv2.0+EDR, Vol. 3, p. 181.

Classification	Definition
unknown	A channel shall be classified as *unknown* if the channel assessment measurements are insufficient to reliably classify the channel, and the channel is not marked as *bad* in the most recent HCI *Set_AFH_Channel_Classification*.
bad	A channel may be classified as *bad* if an ACL or synchronous throughput failure measure associated with it has exceeded a threshold (defined by the particular channel assessment algorithm employed). A channel may also be classified as *bad* if an interference-level measure associated with it, determining the interference level that the link poses upon other systems in the vicinity, has exceeded a threshold (defined by the particular channel assessment algorithm employed). A channel shall be classified as *bad* when it is marked as *bad* in the most recent HCI *Set_AFH_Channel_Classification* command.
good	A channel shall be classified as *good* if it is not either *unknown* or *bad*.

Table 8.6: Channel classification descriptions

	A master with AFH enabled physical links shall determine an *AFH_channel_map* based on any combination of the following information: • Channel classification from local measurements (e.g. active or passive channel assessment in the Controller), if supported and enabled. The Host may enable or disable local measurements using the HCI *Write_AFH_Channel_Classification_Mode* command, defined in the HCI Functional Specification [Part E] Section 7.3.58 on page 537 if HCI is present. • Channel classification information from the Host using the HCI *Set_AFH_channel_classification* command, defined in the HCI Functional Specification [Part E] Section 7.3.58 on page 537 if HCI is present. Channels classified as *bad* in the most recent *AFH_Host_Channel_Classification* shall be marked as *unused* in the *AFH_channel_map*. • Channel classification reports received from slaves in *LMP_channel_classification* PDUs, defined in the LMP Specification [Part C] Section 4.1.5 on page 240. Source: CSv2.0+EDR, Vol. 3, p. 181. Once enabled, the master device periodically updates the set of used and unused channels based on performance measurements and evaluations subsequent to the enabling of AFH. The update may be limited to the initial set of used channels in the first channel map, or it may include all 79 channels in the available band, including those in the first channel map as well as channels marked unused or unknown in that map.

	8.6.7 Hop sequence switching Hop sequence adaptation is controlled by the master and can be set to either *enabled* or *disabled*. Once enabled, hop sequence adaptation shall apply to all logical transports on a physical link. Once enabled, the master may periodically update the set of *used* and *unused* channels as well as disable hop sequence adaptation on a physical link. When a master has multiple physical links the state of each link is independent of all other physical links. When hop sequence adaptation is enabled, the *sequence selection* hop selection kernel input is set to *adapted channel hopping sequence* and the *AFH_channel_map* input is set to the appropriate set of *used* and *unused* channels. Additionally, the *same channel* mechanism shall be used. When hop sequence adaptation is enabled with all channels *used* this is known as AHS(79). When hop sequence adaptation is disabled, the *sequence selection* input of the hop selection kernel is set to *basic channel hopping sequence* (the *AFH_channel_map* input is unused in this case) and the *same channel* mechanism shall not be used. The hop sequence adaptation state shall be changed when the master sends the LMP_set_AFH PDU and a baseband acknowledgement is received. When the baseband acknowledgement is received prior to the hop sequence switch instant, *AFH_Instant*, (See Link Manager Protocol [Part C] Section 4.1.4 on page 237) the hop sequence proceeds as shown in Figure 8.9 on page 178. Source: CSv2.0+EDR, Vol. 3, p. 178.
15[J]. if the number of communications channels from the first set of two or more communications channels is less than a specified number, then:	The adapted piconet uses at least 20 channels, and the Accused Devices may place further restrictions on the requirements for a channel map.

	The adapted piconet physical channel shall use at least N_{min} RF channels (where N_{min} is 20). The adapted piconet physical channel uses the adapted channel hopping sequence described in Section 2.6 on page 82. Adapted piconet physical channels can be used for connected devices that have adaptive frequency hopping (AFH) enabled. There are two distinctions between basic and adapted piconet physical channels. The first is that the same channel mechanism that makes the slave frequency the same as the preceding master transmission. The second aspect is that the adapted piconet physical channel may be based on less than the full 79 frequencies of the basic piconet physical channel. Source: CSv2.0+EDR, Vol. 3, p. 75.
15[K]. selecting, based on third performance data that indicates performance of the plurality of communications channels at a third time that is at or later than the second time and at least a third performance criterion, a second set of two or more communications channels from the plurality of communications channels;	The Accused Devices monitor and classify channels on an ongoing basis and/or according to a schedule.

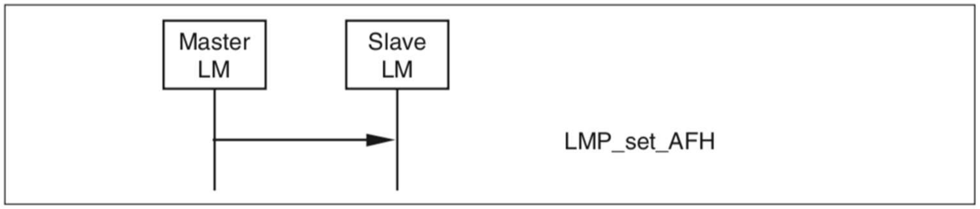
	RF channels are classified as being *unknown, bad or good*. These classifications are determined individually by the master and slaves based on local information (e.g. active or passive channel assessment methods or from the Host via HCI). Information received from other devices via LMP (e.g. an *AFH_channel_map* from a master or a channel classification report from a slave) shall not be included in a device's channel classification. The three possible channel classifications shall be as defined in Table 8.6 on page 181. (table below) Source: CSv2.0+EDR, Vol. 3, p. 181.

Classification	Definition
unknown	A channel shall be classified as *unknown* if the channel assessment measurements are insufficient to reliably classify the channel, and the channel is not marked as *bad* in the most recent HCI *Set_AFH_Channel_Classification*.
bad	A channel may be classified as *bad* if an ACL or synchronous throughput failure measure associated with it has exceeded a threshold (defined by the particular channel assessment algorithm employed). A channel may also be classified as *bad* if an interference-level measure associated with it, determining the interference level that the link poses upon other systems in the vicinity, has exceeded a threshold (defined by the particular channel assessment algorithm employed). A channel shall be classified as *bad* when it is marked as *bad* in the most recent HCI *Set_AFH_Channel_Classification* command.
good	A channel shall be classified as *good* if it is not either *unknown* or *bad*.

Table 8.6: Channel classification descriptions

	A master with AFH enabled physical links shall determine an *AFH_channel_map* based on any combination of the following information: • Channel classification from local measurements (e.g. active or passive channel assessment in the Controller), if supported and enabled. The Host may enable or disable local measurements using the HCI *Write_AFH_Channel_Classification_Mode* command, defined in the HCI Functional Specification [Part E] Section 7.3.58 on page 537 if HCI is present. • Channel classification information from the Host using the HCI *Set_AFH_channel_classification* command, defined in the HCI Functional Specification [Part E] Section 7.3.58 on page 537 if HCI is present. Channels classified as *bad* in the most recent *AFH_Host_Channel_Classification* shall be marked as *unused* in the *AFH_channel_map*. • Channel classification reports received from slaves in *LMP_channel_classification* PDUs, defined in the LMP Specification [Part C] Section 4.1.5 on page 240. Source: CSv2.0+EDR, Vol. 3, p. 181. Once enabled, the master device periodically updates the set of used and unused channels based on performance measurements and evaluations subsequent to the enabling of AFH. The update may be limited to the initial set of used channels in the first channel map, or it may include all 79 channels in the available band, including those in the first channel map as well as channels marked unused or unknown in that map.

	8.6.7 Hop sequence switching Hop sequence adaptation is controlled by the master and can be set to either *enabled* or *disabled*. Once enabled, hop sequence adaptation shall apply to all logical transports on a physical link. Once enabled, the master may periodically update the set of *used* and *unused* channels as well as disable hop sequence adaptation on a physical link. When a master has multiple physical links the state of each link is independent of all other physical links. When hop sequence adaptation is enabled, the *sequence selection* hop selection kernel input is set to *adapted channel hopping sequence* and the *AFH_channel_map* input is set to the appropriate set of *used* and *unused* channels. Additionally, the *same channel* mechanism shall be used. When hop sequence adaptation is enabled with all channels *used* this is known as AHS(79). When hop sequence adaptation is disabled, the *sequence selection* input of the hop selection kernel is set to *basic channel hopping sequence* (the *AFH_channel_map* input is unused in this case) and the *same channel* mechanism shall not be used. The hop sequence adaptation state shall be changed when the master sends the LMP_set_AFH PDU and a baseband acknowledgement is received. When the baseband acknowledgement is received prior to the hop sequence switch instant, *AFH_Instant*, (See Link Manager Protocol [Part C] Section 4.1.4 on page 237) the hop sequence proceeds as shown in Figure 8.9 on page 178. Source: CSv2.0+EDR, Vol. 3, p. 178. When the Accused Device determines that—at a third time and using a third performance criterion—a second set of channels should be used for communication in the piconet, it prepares a new channel map from this set. This occurs, for example, when the second performance criterion evaluation results in a channel map that would contain fewer than two used channels, or would violate another of the Accused Device's threshold requirements for the number of used channels.
15[L]. generating second identification data	The Accused Devices generate second identification data that describe the new channel map to be used for communication in a manner similar to that described above for the initial identification data.

that identifies the second set of two or more communications channels;	*4.1.4.1 Master enables AFH* Prior to enabling AFH the master LM shall pause traffic on the ACL-U logical link (see Baseband Specification, Section 5.3.1, on page 108). The master shall then enable AFH on a physical link by sending the LMP_set_AFH PDU with AFH_mode set to AFH_enabled, the AFH_channel_map parameter containing the set of used and unused channels, and an AFH_instant. The LM shall not calculate the AFH instant until after traffic on the ACL-U logical link has been stopped. The master considers the physical link to be AFH_enabled once the baseband acknowledgement has been received and the AFH_instant has passed. Once the baseband acknowledgement has been received the master shall restart transmission on the ACL-U logical link.  *Sequence 5: Master Enables AFH.* Source: CSv2.0+EDR, Vol. 3, p. 238.

	4.1.4 Adaptive frequency hopping AFH is used to improve the performance of physical links in the presence of interference as well as reducing the interference caused by physical links on other devices in the ISM band. AFH shall only be used during the connection state. **M/O** | **PDU** | **Contents** O(35) Rx, O(43) Tx | LMP_set_AFH | AFH_Instant, AFH_Mode, AFH_Channel_Map *Table 4.4: PDUs used for AFH* The LMP_set_AFH PDU contains three parameters: AFH_Instant, AFH_Mode, and AFH_Channel_Map. The parameter, AFH_Instant, specifies the instant at which the hopset switch will become effective. This is specified as a Bluetooth Clock value of the master's clock, that is available to both devices. The AFH instant is chosen by the master and shall be an even value at least $6*T_{poll}$ or 96 slots (whichever is greater) in the future, where T_{poll} is at least the longest poll interval for all AFH enabled physical links. The AFH_instant shall be within 12 hours of the current clock value. The parameter AFH_Mode, specifies whether AFH shall be enabled or disabled. The parameter AFH_Channel_Map, specifies the set of channels that shall be used if AFH is enabled. Source: CSv2.0+EDR, Vol. 3, p. 237.

AFH_channel _classification	10	multiple bytes	-	This parameter contains 40 2-bit fields. The n^{th} (numbering from 0) such field defines the classification of channels *2n* and *2n+1*, other than the 39th field which just contains the classification of channel 78. Each field interpreted as an integer whose values indicate: 0 = unknown 1 = good 2 = reserved 3 = bad
AFH_channel _map	10	multiple bytes	-	If *AFH_mode* is *AFH_enabled*, this parameter contains 79 1-bit fields, otherwise the contents are reserved. The n^{th} (numbering from 0) such field (in the range 0 to 78) contains the value for channel *n*. Bit 79 is reserved (set to 0 when transmitted and ignored when received) The 1-bit field is interpreted as follows: 0: channel *n* is unused 1: channel *n* is used
AFH_instant	4	u_int32	slots	Bits 27:1 of the Bluetooth master clock value at the time of switching hop sequences. Must be even.

Source: CSv2.0+EDR, Vol. 3, p. 303.

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8.6.7 Hop sequence switching

Hop sequence adaptation is controlled by the master and can be set to either enabled or disabled. Once enabled, hop sequence adaptation shall apply to all logical transports on a physical link. Once enabled, the master may periodically update the set of used and unused channels as well as disable hop sequence adaptation on a physical link. When a master has multiple physical links the state of each link is independent of all other physical links.

When hop sequence adaptation is enabled, the sequence selection hop selection kernel input is set to adapted channel hopping sequence and the AFH_channel_map input is set to the appropriate set of used and unused channels. Additionally, the same channel mechanism shall be used. When hop sequence adaptation is enabled with all channels used this is known as AHS(79).

When hop sequence adaptation is disabled, the sequence selection input of the hop selection kernel is set to basic channel hopping sequence (the AFH_channel_map input is unused in this case) and the same channel mechanism shall not be used.

The hop sequence adaptation state shall be changed when the master sends the LMP_set_AFH PDU and a baseband acknowledgement is received. When the baseband acknowledgement is received prior to the hop sequence switch instant, AFH_Instant, (See Link Manager Protocol [Part C] Section 4.1.4 on page 237) the hop sequence proceeds as shown in Figure 8.9 on page 178.

Source: CSv2.0+EDR, Vol. 3, p. 178.
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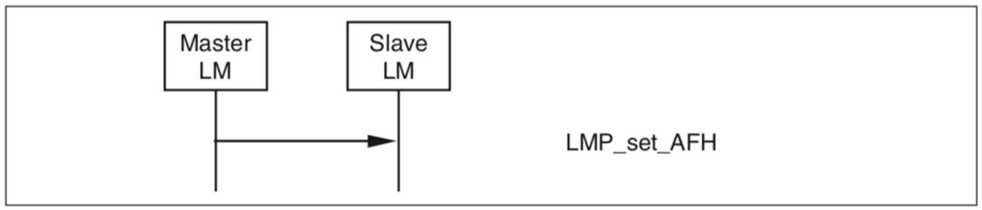
<td>15[M]. providing the second identification data to the participant over one communications channel of the plurality of communications</td>
<td>The new channel map identification data is provided from the master device to all slave devices in the piconet.</td>
</tr>
</table>

channels based on the hopping sequence according to the frequency hopping protocol; and	*4.1.4.1 Master enables AFH* Prior to enabling AFH the master LM shall pause traffic on the ACL-U logical link (see Baseband Specification, Section 5.3.1, on page 108). The master shall then enable AFH on a physical link by sending the LMP_set_AFH PDU with AFH_mode set to AFH_enabled, the AFH_channel_map parameter containing the set of used and unused channels, and an AFH_instant. The LM shall not calculate the AFH instant until after traffic on the ACL-U logical link has been stopped. The master considers the physical link to be AFH_enabled once the baseband acknowledgement has been received and the AFH_instant has passed. Once the baseband acknowledgement has been received the master shall restart transmission on the ACL-U logical link.  *Sequence 5: Master Enables AFH.* Source: CSv2.0+EDR, Vol. 3, p. 238.

	4.1.4 Adaptive frequency hopping AFH is used to improve the performance of physical links in the presence of interference as well as reducing the interference caused by physical links on other devices in the ISM band. AFH shall only be used during the connection state. **M/O** | **PDU** | **Contents** O(35) Rx O(43) Tx | LMP_set_AFH | AFH_Instant, AFH_Mode, AFH_Channel_Map *Table 4.4: PDUs used for AFH* The LMP_set_AFH PDU contains three parameters: AFH_Instant, AFH_Mode, and AFH_Channel_Map. The parameter, AFH_Instant, specifies the instant at which the hopset switch will become effective. This is specified as a Bluetooth Clock value of the master's clock, that is available to both devices. The AFH instant is chosen by the master and shall be an even value at least 6*T_{poll} or 96 slots (whichever is greater) in the future, where T_{poll} is at least the longest poll interval for all AFH enabled physical links. The AFH_instant shall be within 12 hours of the current clock value. The parameter AFH_Mode, specifies whether AFH shall be enabled or disabled. The parameter AFH_Channel_Map, specifies the set of channels that shall be used if AFH is enabled. Source: CSv2.0+EDR, Vol. 3, p. 237.

AFH_channel _classification	10	multiple bytes	-	This parameter contains 40 2-bit fields. The n^{th} (numbering from 0) such field defines the classification of channels *2n* and *2n+1*, other than the 39th field which just contains the classification of channel 78. Each field interpreted as an integer whose values indicate: 0 = unknown 1 = good 2 = reserved 3 = bad
AFH_channel _map	10	multiple bytes	-	If *AFH_mode* is *AFH_enabled*, this parameter contains 79 1-bit fields, otherwise the contents are reserved. The n^{th} (numbering from 0) such field (in the range 0 to 78) contains the value for channel *n*. Bit 79 is reserved (set to 0 when transmitted and ignored when received) The 1-bit field is interpreted as follows: 0: channel *n* is unused 1: channel *n* is used
AFH_instant	4	u_int32	slots	Bits 27:1 of the Bluetooth master clock value at the time of switching hop sequences. Must be even.

Source: CSv2.0+EDR, Vol. 3, p. 303.

	8.6.7 Hop sequence switching Hop sequence adaptation is controlled by the master and can be set to either *enabled* or *disabled*. Once enabled, hop sequence adaptation shall apply to all logical transports on a physical link. Once enabled, the master may periodically update the set of *used* and *unused* channels as well as disable hop sequence adaptation on a physical link. When a master has multiple physical links the state of each link is independent of all other physical links. When hop sequence adaptation is enabled, the *sequence selection* hop selection kernel input is set to *adapted channel hopping sequence* and the *AFH_channel_map* input is set to the appropriate set of *used* and *unused* channels. Additionally, the *same channel* mechanism shall be used. When hop sequence adaptation is enabled with all channels *used* this is known as AHS(79). When hop sequence adaptation is disabled, the *sequence selection* input of the hop selection kernel is set to *basic channel hopping sequence* (the *AFH_channel_map* input is unused in this case) and the *same channel* mechanism shall not be used. The hop sequence adaptation state shall be changed when the master sends the LMP_set_AFH PDU and a baseband acknowledgement is received. When the baseband acknowledgement is received prior to the hop sequence switch instant, *AFH_Instant*, (See Link Manager Protocol [Part C] Section 4.1.4 on page 237) the hop sequence proceeds as shown in Figure 8.9 on page 178. Source: CSv2.0+EDR, Vol. 3, p. 178.
15[N]. communicating with the participant over the second set of two or more communications channels.	When the new channel map takes effect, the Accused Devices communicate with other devices in the piconet over the channels in that map. or time slots. For each reception or transmission event an RF channel is selected by the hop selection kernel (see Section 2.6 on page 82).The maxi- Source: CSv2.0+EDR, Vol. 3, p. 70.

	8.6.7 Hop sequence switching Hop sequence adaptation is controlled by the master and can be set to either *enabled* or *disabled*. Once enabled, hop sequence adaptation shall apply to all logical transports on a physical link. Once enabled, the master may periodically update the set of *used* and *unused* channels as well as disable hop sequence adaptation on a physical link. When a master has multiple physical links the state of each link is independent of all other physical links. When hop sequence adaptation is enabled, the *sequence selection* hop selection kernel input is set to *adapted channel hopping sequence* and the *AFH_channel_map* input is set to the appropriate set of *used* and *unused* channels. Additionally, the *same channel* mechanism shall be used. When hop sequence adaptation is enabled with all channels *used* this is known as AHS(79). When hop sequence adaptation is disabled, the *sequence selection* input of the hop selection kernel is set to *basic channel hopping sequence* (the *AFH_channel_map* input is unused in this case) and the *same channel* mechanism shall not be used. The hop sequence adaptation state shall be changed when the master sends the LMP_set_AFH PDU and a baseband acknowledgement is received. When the baseband acknowledgement is received prior to the hop sequence switch instant, *AFH_Instant*, (See Link Manager Protocol [Part C] Section 4.1.4 on page 237) the hop sequence proceeds as shown in Figure 8.9 on page 178. Source: CSv2.0+EDR, Vol. 3, p. 178. When unused channels are selected as candidate channels by the hop selection kernel, they are remapped to used channels.

	2.6.3.1 Channel re-mapping function When the adapted hop selection kernel is selected, the basic hop selection kernel according to Figure 2.16 on page 86 is initially used to determine an RF channel. If this RF channel is *unused* according to the *AFH_channel_map*, the *unused* RF channel is re-mapped by the re-mapping function to one of the *used* RF channels. If the RF channel determined by the basic hop selection kernel is already in the set of *used* RF channels, no adjustment is made. The hop sequence of the (non-adapted) basic hop equals the sequence of the adapted selection kernel on all locations where *used* RF channels are generated by the basic hop. This property facilitates non-AFH slaves remaining synchronized while other slaves in the piconet are using the adapted hopping sequence. Source: CSv2.0+EDR, Vol. 3, p. 89.

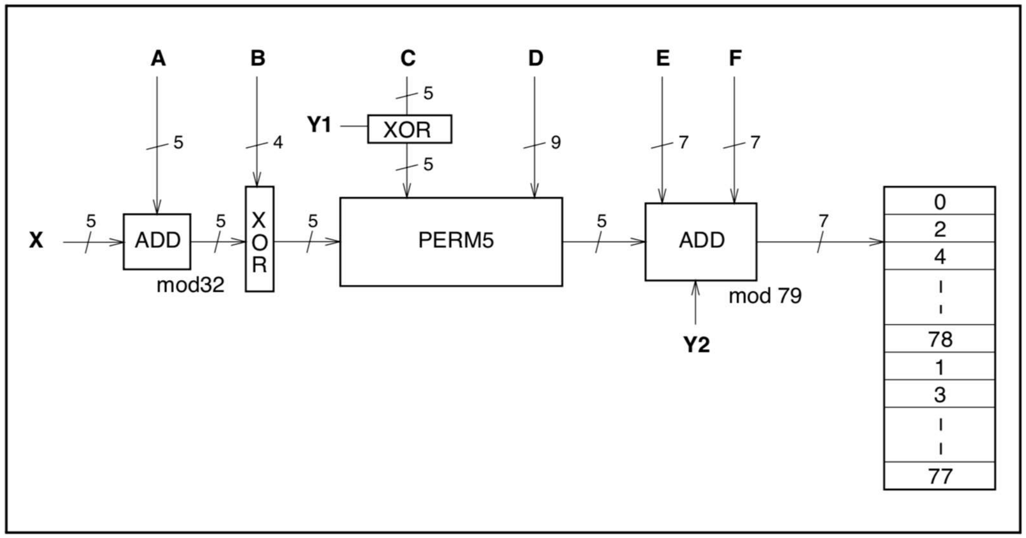
	The basic hop selection kernel shall be as shown in Figure 2.16 on page 86 and is used for the page, page response, inquiry, inquiry response and basic channel hopping selection kernels. In these substates the AFH_channel_map input is unused. The adapted channel hopping selection kernel is described in Section 2.6.3 on page 89. The X input determines the phase in the 32-hop segment, whereas Y1 and Y2 selects between master-to-slave and slave-to-master. The inputs A to D determine the ordering within the segment, the inputs E and F determine the mapping onto the hop frequencies. The kernel addresses a register containing the RF channel indices. This list is ordered so that first all even RF channel indices are listed and then all odd hop frequencies. In this way, a 32-hop segment spans about 64 MHz.  *Figure 2.16: Block diagram of the basic hop selection kernel for the hop system.* The selection procedure consists of an addition, an XOR operation, a permutation operation, an addition, and finally a register selection. In the remainder of this chapter, the notation A_i is used for bit i of the BD_ADDR. Source: CSv2.0+EDR, Vol. 3, p. 86.

Exhibit 4. **Representative claim chart demonstrating infringement by Curtis International Ltd.'s Bluetooth Classic Products.**

U.S. Patent No. 9,883,520 v. Curtis International Ltd.'s Bluetooth Classic Products

Overview

Plaintiff accuses the provision, use, and operation of Curtis International Ltd.'s ("Defendant") Bluetooth Classic Products of directly infringing U.S. Patent No. 9,883,520 (the "'520 Patent"). The term "Accused Devices" means Defendant's Bluetooth Classic Products and all associated interfaces, computer hardware, software and digital content, which includes but is not necessarily limited to the non-limiting example list of products included in *Exhibit 1*.

Plaintiff further accuses Defendant of indirectly infringing the '520 Patent through providing, authorizing and instructing regarding the Accused Devices to others, including its customers. Installing or activating the Accused Devices and the operation thereof directly infringe the asserted claims. Defendant intends to cause infringement by its customers and users. Defendant instructs users to use the Accused Devices in an infringing manner. Defendant enacts contractual protections requiring that the Accused Devices be used in a manner intended by Defendant. Defendant further instructs users to configure and operate the Accused Devices in an infringing manner. Defendant also provides support services for the Accused Devices, including providing instructions, guides, online materials and technical support.

The asserted claims include elements that are implemented, at least in part, by proprietary electronics and software in the Accused Devices. The precise source code, designs, data structures, processes, and algorithms used in them are held secret, at least in part, and are not publicly available in their entirety. An analysis of Defendant's documentation and/or source code may be necessary to fully and accurately describe all infringing features and functionality of the Accused Devices and, accordingly, Plaintiff reserves the right to supplement these contentions once such information is made available to Plaintiff. Furthermore, Plaintiff reserves the right to revise these contentions, including as discovery in the case progresses, in view of the Court's final claim construction in this action and in connection with the provision of its expert reports.

<table>
<tr><th>Claim 1</th><th>Infringement Contention</th></tr>
<tr><td>1[A]. A wireless communications device configured to:</td><td>The Accused Devices are wireless communications devices that certify compliance with the Bluetooth (“BT”) Core Specification (“CS”) Version 2.0+EDR (“CSv2.0+EDR”) or higher. CSv2.0+EDR is available for download at: https://www.bluetooth.org/DocMan/handlers/DownloadDoc.ashx?doc_id=40560. All Bluetooth Core Specifications are available at: https://www.bluetooth.com/specifications/bluetooth-core-specification.

The Accused Devices may function in either master or slave roles in a Bluetooth piconet, as those terms are defined in CS.</td></tr>
<tr><td>1[B]. send packet data to another wireless communications device in a wireless communications network, the packet data specifying a subset of communications channels used for frequency hopping communications of a set of communications channels in a frequency band, the packet data further comprising timing information indicating when to begin using the subset of communications channels for</td><td>Communication in a Bluetooth piconet is in the form of packets.

In basic channel operation, packets are transmitted and received according to a pseudo-random sequence of hopping through 79 RF channels in the available frequency band.

The Bluetooth system operates in the 2.4 GHz ISM band. This frequency band is 2400 - 2483.5 MHz.
<table><tr><th>Regulatory Range</th><th>RF Channels</th></tr><tr><td>2.400-2.4835 GHz</td><td>f=2402+k MHz, k=0,…,78</td></tr></table>Table 2.1: Operating frequency bands

RF channels are spaced 1 MHz and are ordered in channel number k as shown in Table 2.1. In order to comply with out-of-band regulations in each country, a guard band is used at the lower and upper band edge.
<table><tr><th>Lower Guard Band</th><th>Upper Guard Band</th></tr><tr><td>2 MHz</td><td>3.5 MHz</td></tr></table>Table 2.2: Guard Bands

Source: CSv2.0+EDR, Vol. 3, p. 29.

The physical channel used by the piconet is divided into time units known as slots. Packets are positioned in these slots for transmission.</td></tr>
</table>

frequency hopping communications;	The physical channel is sub-divided into time units known as slots. Data is transmitted between Bluetooth devices in packets, that are positioned in these slots. When circumstances permit, a number of consecutive slots may be allocated to a single packet. Frequency hopping takes place between the transmis- Source: CSv2.0+EDR, Vol. 1, p. 13. 3.3.1.1 Overview The basic piconet channel is used for communication between connected devices during normal operation. 3.3.1.2 Characteristics The basic piconet channel is characterized by a pseudo-random sequence hopping through the RF channels. The hopping sequence is unique for the piconet and is determined by the Bluetooth device address of the master. The phase in the hopping sequence is determined by the Bluetooth clock of the master. All Bluetooth devices participating in the piconet are time- and hop-synchronized to the channel. The channel is divided into time slots where each slot corresponds to an RF hop frequency. Consecutive hops correspond to different RF hop frequencies. The time slots are numbered according to the Bluetooth clock of the piconet master. Packets are transmitted by Bluetooth devices participating in the piconet aligned to start at a slot boundary. Each packet starts with the channel's access code, which is derived from the Bluetooth device address of the piconet. Source: CSv2.0+EDR, Vol. 1, p. 35. To mitigate or avoid the effects of interference on particular channels, the Accused Devices switch from basic channel operation (using all 79 channels) to adapted channel operation. In adapted channel operation, a subset of the 79 available channels in the frequency band are used for packet transmission.

	The adapted piconet channel differs from the basic piconet channel in two ways. First the frequencies on which the slaves transmit are the same as the preceding master transmit frequency. In other words the frequency is not recomputed between master and subsequent slave packets. The second way in which the adapted piconet channel differs from the basic piconet channel is that the adapted type can be based on fewer than the full 79 frequencies. A number of frequencies may be excluded from the hopping pattern by being marked as "unused". The remainder of the 79 frequencies are included. The two sequences are the same except that whenever the basic pseudo-random hopping sequence would have selected an unused frequency it is replaced with an alternative chosen from the used set. Source: CSv2.0+EDR, Vol. 1, p. 36. The adapted piconet physical channel shall use at least N_{min} RF channels (where N_{min} is 20). The adapted piconet physical channel uses the adapted channel hopping sequence described in Section 2.6 on page 82. Adapted piconet physical channels can be used for connected devices that have adaptive frequency hopping (AFH) enabled. There are two distinctions between basic and adapted piconet physical channels. The first is that the same channel mechanism that makes the slave frequency the same as the preceding master transmission. The second aspect is that the adapted piconet physical channel may be based on less than the full 79 frequencies of the basic piconet physical channel. Source: CSv2.0+EDR, Vol. 3, p. 75.

When the adapted channel hopping sequence is selected, the *AFH_channel_map* is an additional input to the selection box. The *AFH_channel_map* indicates which channels shall be *used* and which shall be *unused*. These terms are defined in Section 2.6.3 on page 89.

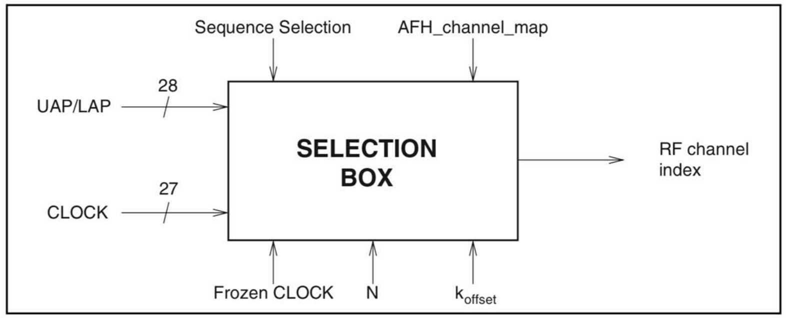


Figure 2.12: General block diagram of hop selection scheme.

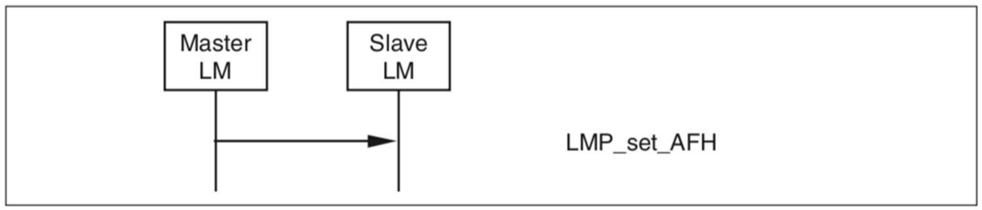
Source: CSv2.0+EDR, Vol. 3, p. 83.

The performance of each channel is evaluated to classify it as shown below.

	The three possible channel classifications shall be as defined in Table 8.6 on page 181. **Classification** / **Definition** *unknown* — A channel shall be classified as *unknown* if the channel assessment measurements are insufficient to reliably classify the channel, and the channel is not marked as *bad* in the most recent HCI *Set_AFH_Channel_Classification*. *bad* — A channel may be classified as *bad* if an ACL or synchronous throughput failure measure associated with it has exceeded a threshold (defined by the particular channel assessment algorithm employed). A channel may also be classified as *bad* if an interference-level measure associated with it, determining the interference level that the link poses upon other systems in the vicinity, has exceeded a threshold (defined by the particular channel assessment algorithm employed). A channel shall be classified as *bad* when it is marked as *bad* in the most recent HCI *Set_AFH_Channel_Classification* command. *good* — A channel shall be classified as *good* if it is not either *unknown* or *bad*. *Table 8.6: Channel classification descriptions* Source: CSv2.0+EDR, Vol. 3, p. 181. To switch from basic to adapted channel operation or to update the channel map currently in use, the Accused Devices transmit packet data comprising (1) a subset of channels to use for frequency hopping communication and (2) timing information indicative of when to begin using the subset to another wireless device in the piconet. For example, the LMP_set_AFH PDU (packet data unit) sent by master devices to slave device contains parameters for AFH_Instant and AFH_channel_map. AFH_channel_map contains the subset of channels to use and associated classifications. AFH_Instant expresses the time at which slave devices shall begin using the new channel map.

4.1.4.1 Master enables AFH

Prior to enabling AFH the master LM shall pause traffic on the ACL-U logical link (see Baseband Specification, Section 5.3.1, on page 108). The master shall then enable AFH on a physical link by sending the LMP_set_AFH PDU with AFH_mode set to AFH_enabled, the AFH_channel_map parameter containing the set of used and unused channels, and an AFH_instant. The LM shall not calculate the AFH instant until after traffic on the ACL-U logical link has been stopped. The master considers the physical link to be AFH_enabled once the baseband acknowledgement has been received and the AFH_instant has passed. Once the baseband acknowledgement has been received the master shall restart transmission on the ACL-U logical link.



Sequence 5: Master Enables AFH.

Source: CSv2.0+EDR, Vol. 3, p. 238.

	4.1.4 Adaptive frequency hopping AFH is used to improve the performance of physical links in the presence of interference as well as reducing the interference caused by physical links on other devices in the ISM band. AFH shall only be used during the connection state. (Table 4.4 below) *Table 4.4: PDUs used for AFH* The LMP_set_AFH PDU contains three parameters: AFH_Instant, AFH_Mode, and AFH_Channel_Map. The parameter, AFH_Instant, specifies the instant at which the hopset switch will become effective. This is specified as a Bluetooth Clock value of the master's clock, that is available to both devices. The AFH instant is chosen by the master and shall be an even value at least 6*T_{poll} or 96 slots (whichever is greater) in the future, where T_{poll} is at least the longest poll interval for all AFH enabled physical links. The AFH_instant shall be within 12 hours of the current clock value. The parameter AFH_Mode, specifies whether AFH shall be enabled or disabled. The parameter AFH_Channel_Map, speci-fies the set of channels that shall be used if AFH is enabled. Source: CSv2.0+EDR, Vol. 3, p. 237.

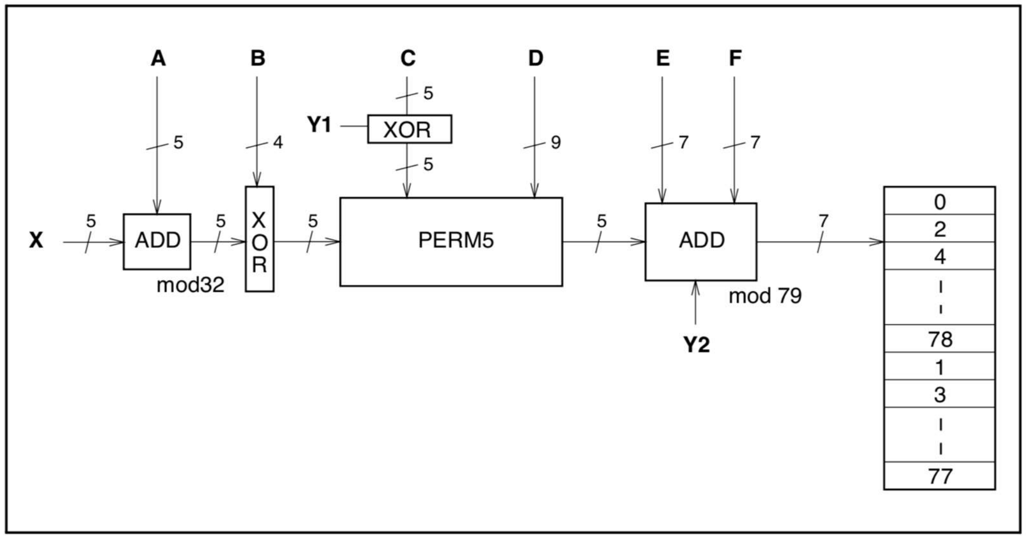
M/O	PDU	Contents
O(35) Rx O(43) Tx	LMP_set_AFH	AFH_Instant, AFH_Mode, AFH_Channel_Map

AFH_channel _classification	10	multiple bytes	-	This parameter contains 40 2-bit fields. The n^{th} (numbering from 0) such field defines the classification of channels *2n* and *2n+1*, other than the 39th field which just contains the classification of channel 78. Each field interpreted as an integer whose values indicate: 0 = unknown 1 = good 2 = reserved 3 = bad
AFH_channel _map	10	multiple bytes	-	If *AFH_mode* is *AFH_enabled*, this parameter contains 79 1-bit fields, otherwise the contents are reserved. The n^{th} (numbering from 0) such field (in the range 0 to 78) contains the value for channel *n*. Bit 79 is reserved (set to 0 when transmitted and ignored when received) The 1-bit field is interpreted as follows: 0: channel *n* is unused 1: channel *n* is used
AFH_instant	4	u_int32	slots	Bits 27:1 of the Bluetooth master clock value at the time of switching hop sequences. Must be even.

Source: CSv2.0+EDR, Vol. 3, p. 303.

	8.6.7 Hop sequence switching Hop sequence adaptation is controlled by the master and can be set to either *enabled* or *disabled*. Once enabled, hop sequence adaptation shall apply to all logical transports on a physical link. Once enabled, the master may periodically update the set of *used* and *unused* channels as well as disable hop sequence adaptation on a physical link. When a master has multiple physical links the state of each link is independent of all other physical links. When hop sequence adaptation is enabled, the *sequence selection* hop selection kernel input is set to *adapted channel hopping sequence* and the *AFH_channel_map* input is set to the appropriate set of *used* and *unused* channels. Additionally, the *same channel* mechanism shall be used. When hop sequence adaptation is enabled with all channels *used* this is known as AHS(79). When hop sequence adaptation is disabled, the *sequence selection* input of the hop selection kernel is set to *basic channel hopping sequence* (the *AFH_channel_map* input is unused in this case) and the *same channel* mechanism shall not be used. The hop sequence adaptation state shall be changed when the master sends the LMP_set_AFH PDU and a baseband acknowledgement is received. When the baseband acknowledgement is received prior to the hop sequence switch instant, *AFH_Instant*, (See Link Manager Protocol [Part C] Section 4.1.4 on page 237) the hop sequence proceeds as shown in Figure 8.9 on page 178. Source: CSv2.0+EDR, Vol. 3, p. 178.
1[C]. identify a communications channel from the set of communications channels;	When the Accused Devices need to communicate with another device in the piconet, as described above, a candidate channel from the available frequency band is identified. For each reception or transmission event an RF channel is selected by the hop selection kernel. When the master device has notified the slave device(s) that adapted frequency hopping is to be used—by, for example, sending the LMP_set_AFH PDU as described above—the basic hop selection kernel is initially used to determine a candidate RF channel. or time slots. For each reception or transmission event an RF channel is selected by the hop selection kernel (see Section 2.6 on page 82).The maxi- Source: CSv2.0+EDR, Vol. 3, p. 70.

	2.6.3.1 Channel re-mapping function When the adapted hop selection kernel is selected, the basic hop selection kernel according to Figure 2.16 on page 86 is initially used to determine an RF channel. If this RF channel is *unused* according to the *AFH_channel_map*, the *unused* RF channel is re-mapped by the re-mapping function to one of the *used* RF channels. If the RF channel determined by the basic hop selection kernel is already in the set of *used* RF channels, no adjustment is made. The hop sequence of the (non-adapted) basic hop equals the sequence of the adapted selection kernel on all locations where *used* RF channels are generated by the basic hop. This property facilitates non-AFH slaves remaining synchronized while other slaves in the piconet are using the adapted hopping sequence. Source: CSv2.0+EDR, Vol. 3, p. 89.

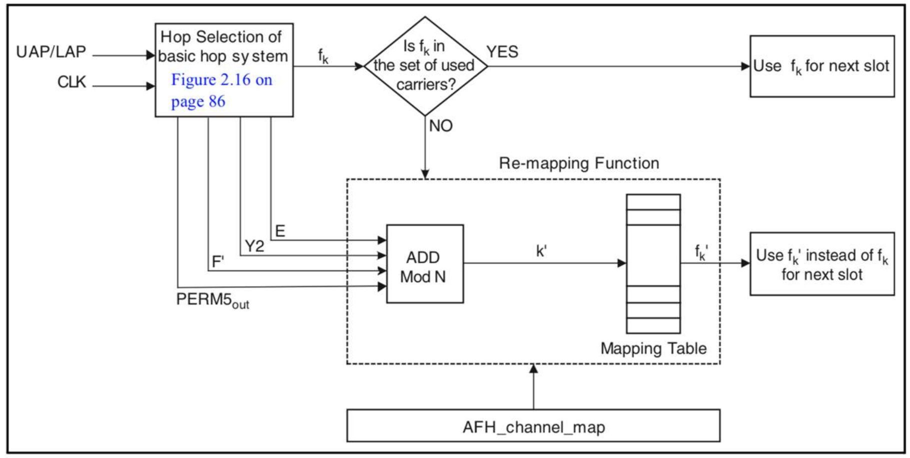
	The basic hop selection kernel shall be as shown in Figure 2.16 on page 86 and is used for the page, page response, inquiry, inquiry response and basic channel hopping selection kernels. In these substates the AFH_channel_map input is unused. The adapted channel hopping selection kernel is described in Section 2.6.3 on page 89. The X input determines the phase in the 32-hop segment, whereas Y1 and Y2 selects between master-to-slave and slave-to-master. The inputs A to D determine the ordering within the segment, the inputs E and F determine the mapping onto the hop frequencies. The kernel addresses a register containing the RF channel indices. This list is ordered so that first all even RF channel indices are listed and then all odd hop frequencies. In this way, a 32-hop segment spans about 64 MHz.  *Figure 2.16: Block diagram of the basic hop selection kernel for the hop system.* The selection procedure consists of an addition, an XOR operation, a permutation operation, an addition, and finally a register selection. In the remainder of this chapter, the notation A_i is used for bit i of the BD_ADDR. Source: CSv2.0+EDR, Vol. 3, p. 86.

1[D]. use the identified communications channel for frequency hopping communications with the other wireless communications device at a time slot at or after the wireless communications device and the other wireless communications device begin using the subset of communications channels for frequency hopping communications, if the identified communications channel is used for frequency hopping communications; and	When the adapted hop selection kernel is selected, the basic hop selection kernel is initially used to determine an RF channel. If this RF channel is unused according to the AFH_channel_map, the unused RF channel is re-mapped by the re-mapping function to one of the used RF channels. If the RF channel determined by the basic hop selection kernel is already in the set of used RF channels, no adjustment is made. The three possible channel classifications shall be as defined in Table 8.6 on page 181. **Classification** — **Definition** *unknown* — A channel shall be classified as *unknown* if the channel assessment measurements are insufficient to reliably classify the channel, and the channel is not marked as *bad* in the most recent HCI *Set_AFH_Channel_Classification*. *bad* — A channel may be classified as *bad* if an ACL or synchronous throughput failure measure associated with it has exceeded a threshold (defined by the particular channel assessment algorithm employed). A channel may also be classified as *bad* if an interference-level measure associated with it, determining the interference level that the link poses upon other systems in the vicinity, has exceeded a threshold (defined by the particular channel assessment algorithm employed). A channel shall be classified as *bad* when it is marked as *bad* in the most recent HCI *Set_AFH_Channel_Classification* command. *good* — A channel shall be classified as *good* if it is not either *unknown* or *bad*. *Table 8.6: Channel classification descriptions* Source: CSv2.0+EDR, Vol. 3, p. 181.

AFH_channel _classification	10	multiple bytes	-	This parameter contains 40 2-bit fields. The *n*th (numbering from 0) such field defines the classification of channels *2n* and *2n+1*, other than the 39th field which just contains the classification of channel 78. Each field interpreted as an integer whose values indicate: 0 = unknown 1 = good 2 = reserved 3 = bad
AFH_channel _map	10	multiple bytes	-	If *AFH_mode* is *AFH_enabled*, this parameter contains 79 1-bit fields, otherwise the contents are reserved. The *n*th (numbering from 0) such field (in the range 0 to 78) contains the value for channel *n*. Bit 79 is reserved (set to 0 when transmitted and ignored when received) The 1-bit field is interpreted as follows: 0: channel *n* is unused 1: channel *n* is used
AFH_instant	4	u_int32	slots	Bits 27:1 of the Bluetooth master clock value at the time of switching hop sequences. Must be even.

Source: CSv2.0+EDR, Vol. 3, p. 303.

	2.6.3.1 Channel re-mapping function When the adapted hop selection kernel is selected, the basic hop selection kernel according to Figure 2.16 on page 86 is initially used to determine an RF channel. If this RF channel is *unused* according to the *AFH_channel_map*, the *unused* RF channel is re-mapped by the re-mapping function to one of the *used* RF channels. If the RF channel determined by the basic hop selection kernel is already in the set of *used* RF channels, no adjustment is made. The hop sequence of the (non-adapted) basic hop equals the sequence of the adapted selection kernel on all locations where *used* RF channels are generated by the basic hop. This property facilitates non-AFH slaves remaining synchronized while other slaves in the piconet are using the adapted hopping sequence. Source: CSv2.0+EDR, Vol. 3, p. 89. A block diagram of the re-mapping mechanism is shown in Figure 2.20 on page 90. The re-mapping function is a post-processing step to the selection kernel from Figure 2.16 on page 86, denoted as 'Hop selection of the basic hop'. The output f_k of the basic hop selection kernel is an RF channel number that ranges between 0 and 78. This RF channel will either be in the set of *used* RF channels or in the set of *unused* RF channels. Source: CSv2.0+EDR, Vol. 3, p. 89. Thus, when the identified channel is a used channel, logic proceeds along the "YES" branch of the "Is f_k in the set of used carriers" decision in the diagram below.

	 *Figure 2.20: Block diagram of adaptive hop selection mechanism* When an unused RF channel is generated by the basic hop selection mechanism, it is re-mapped to the set of *used* RF channels as follows. A new index *k'* ∊ {0, 1,..., *N*-1} is calculated using some of the parameters from the basic hop selection kernel: $k' = (PERM5_{out} + E + F' + Y2) \bmod N$ where *F'* is defined in Table 2.2 on page 91. The index *k'* is then used to select the re-mapped channel from a mapping table that contains all of the even *used* RF channels in ascending order followed by all the odd *used* RF channels in ascending order (i.e., the mapping table of Figure 2.16 on page 86 with all the *unused* RF channels removed). Source: CSv2.0+EDR, Vol. 3, p. 90.
1[E]. use a communications channel in the subset of communications channels for frequency hopping	When the RF channel initially selected by the hop selection kernel as described above is an <u>unused</u> channel according to the AFH_channel_map (i.e., it is not used for frequency hopping communications), it is re-mapped by the re-mapping function to one of the used RF channels (i.e., one of the subset of communications channels for frequency hopping communications). If the RF channel determined by the basic hop selection kernel is already in the set of used RF channels, no adjustment is made.

<table>
<tr>
<td>communications with the other wireless communications device at the time slot, if the identified communications channel is not used for frequency hopping communications.</td>
<td>

The three possible channel classifications shall be as defined in Table 8.6 on page 181.

Classification	Definition
unknown	A channel shall be classified as *unknown* if the channel assessment measurements are insufficient to reliably classify the channel, and the channel is not marked as *bad* in the most recent HCI *Set_AFH_Channel_Classification*.
bad	A channel may be classified as *bad* if an ACL or synchronous throughput failure measure associated with it has exceeded a threshold (defined by the particular channel assessment algorithm employed). A channel may also be classified as *bad* if an interference-level measure associated with it, determining the interference level that the link poses upon other systems in the vicinity, has exceeded a threshold (defined by the particular channel assessment algorithm employed). A channel shall be classified as *bad* when it is marked as *bad* in the most recent HCI *Set_AFH_Channel_Classification* command.
good	A channel shall be classified as *good* if it is not either *unknown* or *bad*.

Table 8.6: Channel classification descriptions

Source: CSv2.0+EDR, Vol. 3, p. 181.

2.6.3.1 Channel re-mapping function

When the adapted hop selection kernel is selected, the basic hop selection kernel according to Figure 2.16 on page 86 is initially used to determine an RF channel. If this RF channel is *unused* according to the *AFH_channel_map*, the *unused* RF channel is re-mapped by the re-mapping function to one of the *used* RF channels. If the RF channel determined by the basic hop selection kernel is already in the set of *used* RF channels, no adjustment is made. The hop sequence of the (non-adapted) basic hop equals the sequence of the adapted selection kernel on all locations where *used* RF channels are generated by the basic hop. This property facilitates non-AFH slaves remaining synchronized while other slaves in the piconet are using the adapted hopping sequence.

</td>
</tr>
</table>

	Source: CSv2.0+EDR, Vol. 3, p. 89. A block diagram of the re-mapping mechanism is shown in Figure 2.20 on page 90. The re-mapping function is a post-processing step to the selection kernel from Figure 2.16 on page 86, denoted as 'Hop selection of the basic hop'. The output f_k of the basic hop selection kernel is an RF channel number that ranges between 0 and 78. This RF channel will either be in the set of *used* RF channels or in the set of *unused* RF channels. Source: CSv2.0+EDR, Vol. 3, p. 89. When the identified channel is an unused channel, logic proceeds along the "No" branch of the "Is f_k in the set of used carriers" decision in the diagram below, and enters the "Re-mapping Function" which takes the AFH_channel_map as input.

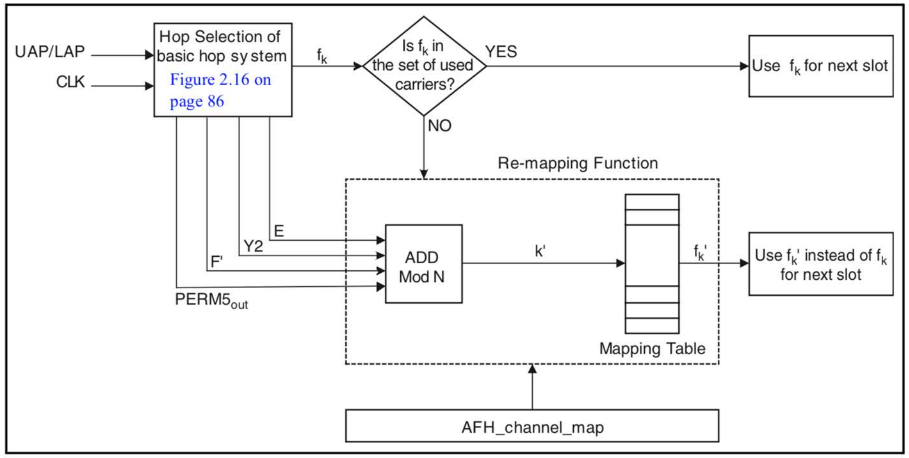


Figure 2.20: Block diagram of adaptive hop selection mechanism

When an unused RF channel is generated by the basic hop selection mechanism, it is re-mapped to the set of *used* RF channels as follows. A new index k' $\in$ {0, 1,..., N-1} is calculated using some of the parameters from the basic hop selection kernel:

$$k' = (PERM5_{out} + E + F' + Y2) \bmod N$$

where F' is defined in Table 2.2 on page 91. The index k' is then used to select the re-mapped channel from a mapping table that contains all of the even *used* RF channels in ascending order followed by all the odd *used* RF channels in ascending order (i.e., the mapping table of Figure 2.16 on page 86 with all the *unused* RF channels removed).

Source: CSv2.0+EDR, Vol. 3, p. 90.

The mapping table in Figure 2.20 above—used by the remapping function to select a used channel in AFH mode—is similar to the mapping table used by the basic hop selection kernel (at the far right in the diagram below), but has all the unused RF channels removed.

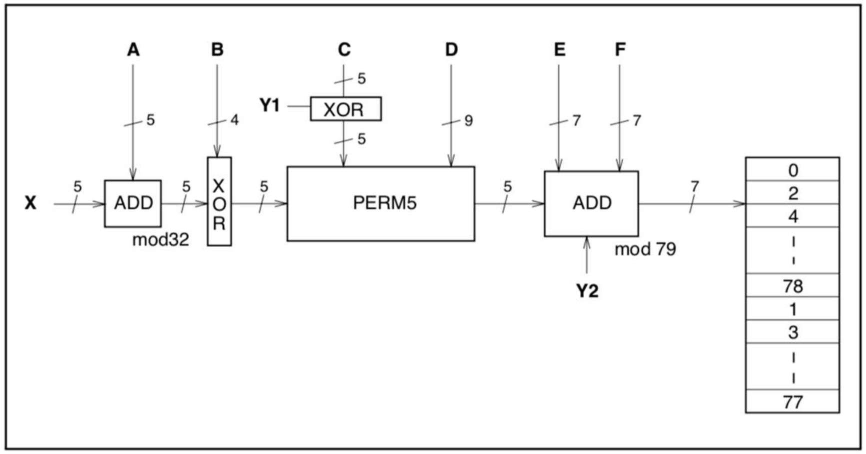
	 *Figure 2.16: Block diagram of the basic hop selection kernel for the hop system.* Source: CSv2.0+EDR, Vol. 3, p. 86.

Exhibit 5. **Representative claim chart demonstrating infringement by by Curtis International Ltd.'s Bluetooth Low Energy Products**

U.S. Patent No. 7,027,418 v. Curtis International Ltd.'s Bluetooth Low Energy Products

Overview

Plaintiff accuses the provision, use, and operation of Curtis International Ltd.'s (“Defendant”) Bluetooth Low Energy Products of directly infringing U.S. Patent No. 7,027,418 (the “'418 Patent”). The term “Accused Devices” means Defendant's Bluetooth Low Energy Products and all associated interfaces, computer hardware, software and digital content, which includes but is not necessarily limited to the non-limiting example list of products included in *Exhibit 2*.

Plaintiff further accuses Defendant of indirectly infringing the '418 Patent through providing, authorizing and instructing regarding the Accused Devices to others, including its customers. Installing or activating the Accused Devices and the operation thereof directly infringe the asserted claims. Defendant intends to cause infringement by its customers and users. Defendant instructs users to use the Accused Devices in an infringing manner. Defendant enacts contractual protections requiring that the Accused Devices be used in a manner intended by Defendant. Defendant further instructs users to configure and operate the Accused Devices in an infringing manner. Defendant also provides support services for the Accused Devices, including providing instructions, guides, online materials and technical support.

The asserted claims include elements that are implemented, at least in part, by proprietary electronics and software in the Accused Devices. The precise source code, designs, data structures, processes, and algorithms used in them are held secret, at least in part, and are not publicly available in their entirety. An analysis of Defendant's documentation and/or source code may be necessary to fully and accurately describe all infringing features and functionality of the Accused Devices and, accordingly, Plaintiff reserves the right to supplement these contentions once such information is made available to Plaintiff. Furthermore, Plaintiff reserves the right to revise these contentions, including as discovery in the case progresses, in view of the Court's final claim construction in this action and in connection with the provision of its expert reports.

Claim 1	Infringement Contention
15[A]. A method for communicating with a participant in a communications arrangement, the method comprising the computer-implemented steps of:	The Accused Devices are wireless communications devices that certify compliance with the Bluetooth ("BT") Core Specification ("CS") Version 4.0 ("CSv4.0") or higher. CSv4.0 is available for download at: https://www.bluetooth.org/docman/handlers/downloaddoc.ashx?doc_id=229737. All Bluetooth Core Specifications are available at: https://www.bluetooth.com/specifications/bluetooth-core-specification. The Accused Devices may function in either master or slave roles in a Bluetooth Low Energy ("BLE") piconet, as those terms are defined in CS.
15[B]. selecting, based on first performance data that indicates performance of a plurality of communications channels at a first time and at least a first performance criterion, a first set of two or more communications channels from the plurality of communications channels;	The Accused Devices classify channels as unknown, bad, or good, based upon performance. Channel classification is expressed in a channel map, which contains at least two used (good) channels. *4.5.8.1 Channel Classification* The master's Link Layer shall classify data channels into *used channels* (used for the connection) and *unused channels* (not used for the connection). This is called the channel map. The minimum number of used channels shall be 2. The Host may provide channel classification information to the Link Layer. The Link Layer may use the information provided by the Host. The slave shall receive the channel map from the master in the CONNECT_REQ PDU. If the master changes the channel map it shall notify the slave as specified in Section 5.1.2. Source: CSv4.0, Vol. 6, p. 74.
15[C]. generating first identification data that identifies the first set of two or more communications	Communication in a Bluetooth piconet is in the form of packets. In basic channel operation, packets are transmitted and received according to a pseudo-random sequence of hopping through 37 RF channels in the available frequency band.

channels;	**1.2 OVERVIEW OF BLUETOOTH LOW ENERGY OPERATION** Like the BR/EDR radio, the LE radio operates in the unlicensed 2.4 GHz ISM band. The LE system employs a frequency hopping transceiver to combat interference and fading and provides many FHSS carriers. LE radio operation uses a shaped, binary frequency modulation to minimize transceiver complexity. The symbol rate is 1 Megasymbol per second (Ms/s) supporting the bit rate of 1 Megabit per second (Mb/s). LE employs two multiple access schemes: Frequency division multiple access (FDMA) and time division multiple access (TDMA). Forty (40) physical channels, separated by 2 MHz, are used in the FDMA scheme. Three (3) are used as advertising channels and 37 are used as data channels. A TDMA based polling scheme is used in which one device transmits a packet at a predetermined time and a corresponding device responds with a packet after a predetermined interval. Source: CSv4.0, Vol. 1, p. 20. As specified in Part A, Section 2, 40 RF Channels are defined in the 2.4GHz ISM band. These RF Channels are allocated into two LE physical channels: advertising and data. The advertising physical channel uses three RF channels for discovering devices, initiating a connection and broadcasting data. The data physical channel uses up to 37 (see Section 4.5.8) RF channels for communication between connected devices. Each of these RF Channels is allocated a unique channel index (see Section 1.4.1). Two devices that wish to communicate use a shared physical channel. To achieve this, their transceivers must be tuned to the same RF Channel at the same time. Source: CSv4.0, Vol. 6, p. 34. Communication between devices is in the form of packets. For example, the format of relevant Link Layer packets is shown below.

2.1 PACKET FORMAT

The Link Layer has only one packet format used for both advertising channel packets and data channel packets.

The packet format is shown in Figure 2.1. Each packet consists of four fields: the preamble, the Access Address, the PDU, and the CRC.

LSB MSB

Preamble (1 octet)	Access Address (4 octets)	PDU (2 to 39 octets)	CRC (3 octets)

Figure 2.1: Link Layer packet format

The preamble is 1 octet and the Access Address is 4 octets. The PDU range is from 2 to a maximum of 39 octets. The CRC is 3 octets.

The Preamble is transmitted first, followed by the Access Address, followed by the PDU followed by the CRC.

Source: CSv4.0, Vol. 6, pp. 36.

The Link Layer specification of the BT LE Link Layer governs communication between devices in a piconet. Packets in the Link Layer specification are Little Endian, with the least significant bit in the leftmost position. Examples herein from the specification should be interpreted to comply with this format.

	1.2 BIT ORDERING The bit ordering when defining fields within the packet or Protocol Data Unit (PDU) in the Link Layer specification follows the Little Endian format. The following rules apply: • The Least Significant Bit (LSB) corresponds to b_0 • The LSB is the first bit sent over the air • In illustrations, the LSB is shown on the left side Furthermore, data fields defined in the Link Layer, such as the PDU header fields, shall be transmitted with the LSB first. For instance, a 3-bit parameter *X=3* is sent as: $b_0b_1b_2 = 110$ Source: CSv4.0, Vol. 6, p. 32. A grouping of two or more devices for communication is known as a piconet. In order to establish a piconet, an initiator device responds to an advertiser device's broadcast of connectable advertising events. The advertiser receives and accepts the initiator's request for connection, and a piconet comprising the two devices is formed. The initiator becomes the master device, and the advertiser becomes the slave device. Devices that transmit advertising packets on the advertising PHY channels are referred to as **advertisers**. Devices that receive advertising on the advertising channels without the intention to connect to the advertising device are referred to as **scanners**. Transmissions on the advertising PHY channels occur in advertising events. At the start of each advertising event, the advertiser sends an advertising packet corresponding to the advertising event type. Depending on the type of advertising packet, the scanner may make a request to the advertiser on the same advertising PHY channel which may be followed by a response from the advertiser on the same advertising PHY channel. The advertising PHY channel changes on the next advertising packet sent by the advertiser in the same advertising event. The advertiser may end the advertising event at any time during the event. The first advertising PHY channel is used at the start of the next advertising event.

	Source: CSv4.0, Vol. 1, p. 20. Devices that need to form a connection to another device listen for connectable advertising packets. Such devices are referred to as **initiators**. If the advertiser is using a connectable advertising event, an initiator may make a connection request using the same advertising PHY channel on which it received the connectable advertising packet. The advertising event is ended and connection events begin if the advertiser receives and accepts the request for a connection be initiated. Once a connection is established, the initiator becomes the **master** device in what is referred to as a **piconet** and the advertising device becomes the **slave** device. Connection events are used to send data packets between the master and slave devices. In connection events, channel hopping occurs at the start of each connection event. Within a connection event, the master and slave alternate sending data packets using the same data PHY channel. The master initiates the beginning of each connection event and can end each connection event at any time. Source: CSv4.0, Vol. 1, p. 21.

	The Link Layer in the Advertising State will be transmitting advertising channel packets and possibly listening to and responding to responses triggered by these advertising channel packets. A device in the Advertising State is known as an advertiser. The Advertising State can be entered from the Standby State. The Link Layer in the Scanning State will be listening for advertising channel packets from devices that are advertising. A device in the Scanning State is known as a scanner. The Scanning State can be entered from the Standby State. The Link Layer in the Initiating State will be listening for advertising channel packets from a specific device(s) and responding to these packets to initiate a connection with another device. A device in the Initiating State is known as an initiator. The Initiating State can be entered from the Standby State. The Connection State can be entered either from the Initiating State or the Advertising State. A device in the Connection State is known as being in a connection. Within the Connection State, two roles are defined: • Master Role • Slave Role Source: CSv4.0, Vol. 6, p. 31. **4.5 CONNECTION STATE** The Link Layer enters the Connection State when an initiator sends a CONNECT_REQ PDU to an advertiser or an advertiser receives a CONNECT_REQ PDU from an initiator. After entering the Connection State, the connection is considered to be created. The connection is not considered to be established at this point. A con- Source: CSv4.0, Vol. 6, p. 67.

The structure of the CONNECT_REQ PDU, which initiates the formation of a piconet, is shown below.

2.3.3 Initiating PDUs

The following advertising channel PDU Type is called the initiating PDU:

- CONNECT_REQ

This PDU is sent by the Link Layer in the Initiating State and received by the Link Layer in the Advertising State.

2.3.3.1 CONNECT_REQ

The CONNECT_REQ PDU has the Payload as shown in Figure 2.10. TxAdd in the Flags field indicates whether the initiator's device address in the InitA field is public (TxAdd = 0) or random (TxAdd = 1). The RxAdd in the Flags field indicates whether the advertiser's device address in the AdvA field is public (RxAdd = 0) or random (RxAdd = 1).

Payload		
InitA (6 octets)	AdvA (6 octets)	LLData (22 octets)

Figure 2.10: CONNECT_REQ PDU payload

Source: CSv4.0, Vol. 6, p. 42.

The CONNECT_REQ PDU packet contains an LLData field, the structure of which is shown below.

LLData									
AA (4 octets)	CRCInit (3 octets)	WinSize (1 octet)	WinOffset (2 octets)	Interval (2 octets)	Latency (2 octets)	Timeout (2 octets)	ChM (5 octets)	Hop (5 bits)	SCA (3 bits)

Figure 2.11: LLData field structure in CONNECT_REQ PDU's payload

Source: CSv4.0, Vol. 6, p. 43.

The LLData field further contains several fields which identify a set of two or more channels to be used for frequency hopping communication by the piconet. This communication is according to a pattern that is a specific ordering of data channels (by index position) in the available frequency band. The ordered channel set may be may be adjusted by the master to exclude one or more channels in use by interfering devices.

> Devices in a piconet use a specific frequency hopping pattern, which is algorithmically determined by a field contained in the connection request sent by an initiating device. The initiating device provides the synchronization reference known as a hop interval. The hopping pattern used in LE is a pseudo-random ordering of the 37 frequencies in the ISM band. The hopping pattern can be adapted to exclude a portion of the frequencies that are used by interfering devices. The adaptive hopping technique improves Bluetooth co-existence with

Source: CSv4.0, Vol. 1, p. 21.

> The LE piconet channel is similar to the BR/EDR adapted piconet channel in that the set of PHY channels used can be modified to avoid interference. The set of used channels in the channel map is established by the master during connection setup. While in a connection the master can change the channel map when necessary to avoid new interferers.
>
> There are 37 LE piconet channels. The master can reduce this number through the channel map indicating the used channels. When the hopping pattern hits

Source: CSv4.0, Vol. 1, p. 55.

A sample indexing of RF channels to data channel and advertising channel indices is shown below.

	Table 1.2 shows the mapping from RF Channel to Data Channel Index and Advertising Channel Index. It also shows the allocation of channel type to each RF Channel.

RF Channel	RF Center Frequency	Channel Type	Data Channel Index	Advertising Channel Index
0	2402 MHz	Advertising channel		37
1	2404 MHz	Data channel	0	
2	2406 MHz	Data channel	1	
...	...	Data channels	...	
11	2424 MHz	Data channel	10	
12	2426 MHz	Advertising channel		38
13	2428 MHz	Data channel	11	
14	2430 MHz	Data channel	12	
...	...	Data channels	...	
38	2478 MHz	Data channel	36	
39	2480 MHz	Advertising channel		39

Table 1.2: Mapping of RF Channel to Data Channel Index and Advertising Channel Index

Source: CSv4.0, Vol. 6, p. 35.

The LLData field contains a ChM field, which is described below. The ChM field contains an initial channel map, which specifies a subset of channels for frequency hopping communication. For example, channels are classified as used or unused, and are indexed in the data channel index.

	• The ChM field shall contain the channel map indicating *Used* and *Unused* data channels. Every channel is represented with a bit positioned as per the data channel index as defined in Section 1.4.1. The LSB represents data channel index 0 and the bit in position 36 represents data channel index 36. A bit value of '0' indicates that the channel is *Unused*. A bit value of '1' indicates that the channel is *Used*. The bits in positions 37, 38 and 39 are Reserved for Future Use. Note: When mapping from RF Channels to data channel index, care should be taken to remember that there is a gap where the second advertising channel is placed. • The Hop field shall be set to indicate the *hopIncrement* used in the data channel selection algorithm as defined in Section 4.5.8.2. It shall have a random value in the range of 5 to 16. Source: CSv4.0, Vol. 6, p. 43.
15[D]. providing the first identification data to the participant;	The channel map identification data is provided from the master device to all slave devices in the piconet in CONNECT_REQ.LLData.ChM.

	2.3.3 Initiating PDUs The following advertising channel PDU Type is called the initiating PDU: • CONNECT_REQ This PDU is sent by the Link Layer in the Initiating State and received by the Link Layer in the Advertising State. *2.3.3.1 CONNECT_REQ* The CONNECT_REQ PDU has the Payload as shown in Figure 2.10. TxAdd in the Flags field indicates whether the initiator's device address in the InitA field is public (TxAdd = 0) or random (TxAdd = 1). The RxAdd in the Flags field indicates whether the advertiser's device address in the AdvA field is public (RxAdd = 0) or random (RxAdd = 1). Payload: InitA (6 octets) | AdvA (6 octets) | LLData (22 octets) *Figure 2.10: CONNECT_REQ PDU payload* Source: CSv4.0, Vol. 6, p. 42. The CONNECT_REQ PDU packet contains an LLData field, the structure of which is shown below. LLData: AA (4 octets) | CRCInit (3 octets) | WinSize (1 octet) | WinOffset (2 octets) | Interval (2 octets) | Latency (2 octets) | Timeout (2 octets) | ChM (5 octets) | Hop (5 bits) | SCA (3 bits) *Figure 2.11: LLData field structure in CONNECT_REQ PDU's payload* Source: CSv4.0, Vol. 6, p. 43.

Payload

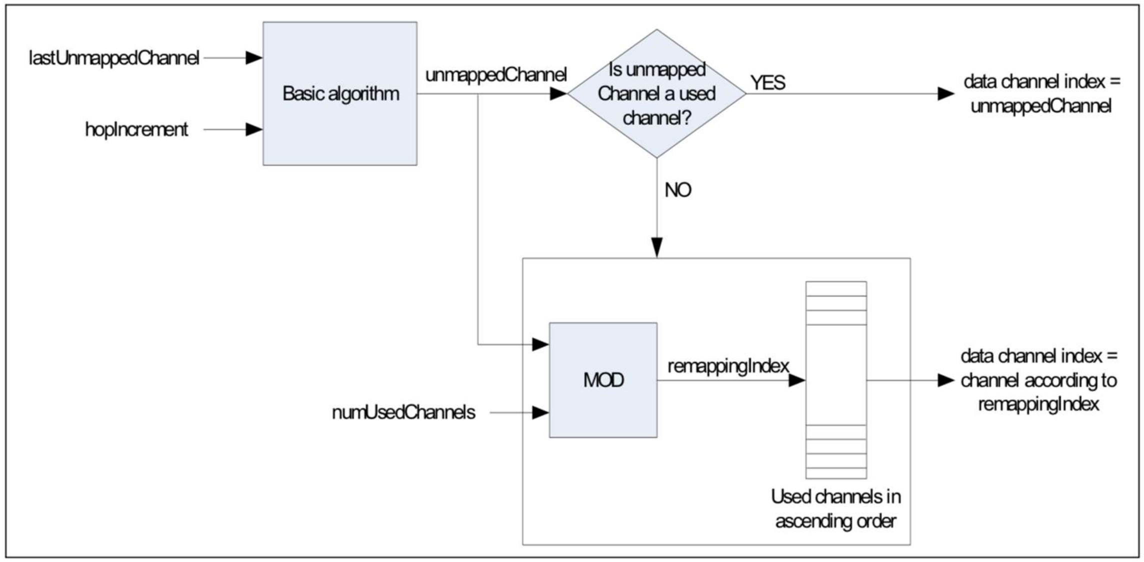
InitA	AdvA	LLData
(6 octets)	(6 octets)	(22 octets)

LLData

AA	CRCInit	WinSize	WinOffset	Interval	Latency	Timeout	ChM	Hop	SCA
(4 octets)	(3 octets)	(1 octet)	(2 octets)	(2 octets)	(2 octets)	(2 octets)	(5 octets)	(5 bits)	(3 bits)

	The LE piconet channel is similar to the BR/EDR adapted piconet channel in that the set of PHY channels used can be modified to avoid interference. The set of used channels in the channel map is established by the master during connection setup. While in a connection the master can change the channel map when necessary to avoid new interferers. There are 37 LE piconet channels. The master can reduce this number through the channel map indicating the used channels. When the hopping pattern hits Source: CSv4.0, Vol. 1, p. 55. • The ChM field shall contain the channel map indicating *Used* and *Unused* data channels. Every channel is represented with a bit positioned as per the data channel index as defined in Section 1.4.1. The LSB represents data channel index 0 and the bit in position 36 represents data channel index 36. A bit value of ‘0’ indicates that the channel is *Unused*. A bit value of ‘1’ indicates that the channel is *Used*. The bits in positions 37, 38 and 39 are Reserved for Future Use. Note: When mapping from RF Channels to data channel index, care should be taken to remember that there is a gap where the second advertising channel is placed. • The Hop field shall be set to indicate the *hopIncrement* used in the data channel selection algorithm as defined in Section 4.5.8.2. It shall have a random value in the range of 5 to 16. Source: CSv4.0, Vol. 6, p. 43.
15[E]. communicating with the participant over the first set of two or more communications channels;	Communication between devices proceeds using the channels identified in the channel map.

	Devices in a piconet use a specific frequency hopping pattern, which is algorithmically determined by a field contained in the connection request sent by an initiating device. The initiating device provides the synchronization reference known as a hop interval. The hopping pattern used in LE is a pseudo-random ordering of the 37 frequencies in the ISM band. The hopping pattern can be adapted to exclude a portion of the frequencies that are used by interfering devices. The adaptive hopping technique improves Bluetooth co-existence with Source: CSv4.0, Vol. 1, p. 21. The LE piconet channel is similar to the BR/EDR adapted piconet channel in that the set of PHY channels used can be modified to avoid interference. The set of used channels in the channel map is established by the master during connection setup. While in a connection the master can change the channel map when necessary to avoid new interferers. There are 37 LE piconet channels. The master can reduce this number through the channel map indicating the used channels. When the hopping pattern hits Source: CSv4.0, Vol. 1, p. 55. When unused channels are selected as candidate channels by the hop selection kernel, they are remapped to used channels.

	The complete procedure is as shown in Figure 4.14.  *Figure 4.14: Block diagram of data channel selection algorithm* Source: CSv4.0, Vol. 6, p. 75.

	<u>*4.5.8.2 Channel Selection*</u> The channel selection algorithm consists of two stages: calculation of the unmapped channel index followed by mapping this index to a data channel index from the set of *used channels*. The *unmappedChannel* and *lastUnmappedChannel* are the unmapped channel indices of two consecutive connection events. The *unmappedChannel* is the unmapped channel index for the current connection event. The *lastUnmappedChannel* is the unmapped channel index of the previous connection event. The *lastUnmappedChannel* shall be '0' for the first connection event of a connection. At the start of a connection event, *unmappedChannel* shall be calculated using the following basic algorithm: *unmappedChannel* = (*lastUnmappedChannel* + *hopIncrement*) mod 37 When a connection event closes, the *lastUnmappedChannel* shall be set to the value of the *unmappedChannel*. If the *unmappedChannel* is a *used channel* according to the channel map, the channel selection algorithm shall use the *unmappedChannel* as the data channel index for the connection event. If the *unmappedChannel* is an *unused channel* according to the channel map, the *unmappedChannel* shall be re-mapped to one of the used channels in the channel map using the following algorithm: *remappingIndex* = *unmappedChannel* mod *numUsedChannels* Source: CSv4.0, Vol. 6, p. 74.

	where *numUsedChannels* is the number of used channels in the channel map. A remapping table is built that contains all the *used channels* in ascending order, indexed from zero. The *remappingIndex* is then used to select the data channel index for the connection event from the remapping table. Source: CSv4.0, Vol. 6, p. 75. Adaptive frequency hopping makes it possible for a given packet to be remapped from a known bad channel to a known good channel so that the interference from other devices is reduced. To do this, a channel map of good and bad channels is kept in both devices. If the channel that would have been chosen by using Equation 7-3 is a good channel, then that channel is used; if the channel that would have been chosen is a bad channel, then it is remapped onto the set of good channels, as depicted in Figure 7–15. A minimum of two data channels must be marked as good by a master. Suppose, for example, that a Bluetooth low energy device is in the same area as a Wi-Fi channel 1 access point that is streaming data to another Wi-Fi device. The Bluetooth low energy device would mark Link Layer data channels 0 to 8 as bad channels. This means that when the two devices are communicating, they would cycle through the channels and remap these channels to a set of good channels, as shown in Table 7–4 and Figure 7–16. Source: Heydon, Robin, Bluetooth Low Energy, The Developer's Handbook 88 (2013).

Table 7–4 An Example of Adaptive Frequency Channel Remapping

Original Channel	Good/Bad	Remapped Channel
0	Bad	9
13	Good	13
26	Good	26
2	Bad	11
15	Good	15
28	Good	28
4	Bad	13
17	Good	17
30	Good	30
6	Bad	15
19	Good	19
32	Good	32
8	Bad	17

Source: Heydon, Robin, Bluetooth Low Energy, The Developer's Handbook 89 (2013).

15[F]. wherein the plurality of communications channels correspond to a set of frequencies to be used based on a hopping sequence according to a frequency hopping	The RF channels used for transmitting and receiving in the piconet correspond to a set of frequencies according to a pseudo-random sequence of hopping through 37 RF channels in the available frequency band.

protocol;	**1.2 OVERVIEW OF BLUETOOTH LOW ENERGY OPERATION** Like the BR/EDR radio, the LE radio operates in the unlicensed 2.4 GHz ISM band. The LE system employs a frequency hopping transceiver to combat interference and fading and provides many FHSS carriers. LE radio operation uses a shaped, binary frequency modulation to minimize transceiver complexity. The symbol rate is 1 Megasymbol per second (Ms/s) supporting the bit rate of 1 Megabit per second (Mb/s). LE employs two multiple access schemes: Frequency division multiple access (FDMA) and time division multiple access (TDMA). Forty (40) physical channels, separated by 2 MHz, are used in the FDMA scheme. Three (3) are used as advertising channels and 37 are used as data channels. A TDMA based polling scheme is used in which one device transmits a packet at a predetermined time and a corresponding device responds with a packet after a predetermined interval. Source: CSv4.0, Vol. 1, p. 20. As specified in Part A, Section 2, 40 RF Channels are defined in the 2.4GHz ISM band. These RF Channels are allocated into two LE physical channels: advertising and data. The advertising physical channel uses three RF channels for discovering devices, initiating a connection and broadcasting data. The data physical channel uses up to 37 (see Section 4.5.8) RF channels for communication between connected devices. Each of these RF Channels is allocated a unique channel index (see Section 1.4.1). Two devices that wish to communicate use a shared physical channel. To achieve this, their transceivers must be tuned to the same RF Channel at the same time. Source: CSv4.0, Vol. 6, p. 34.

	Devices in a piconet use a specific frequency hopping pattern, which is algorithmically determined by a field contained in the connection request sent by an initiating device. The initiating device provides the synchronization reference known as a hop interval. The hopping pattern used in LE is a pseudo-random ordering of the 37 frequencies in the ISM band. The hopping pattern can be adapted to exclude a portion of the frequencies that are used by interfering devices. The adaptive hopping technique improves Bluetooth co-existence with Source: CSv4.0, Vol. 1, p. 21. The LE piconet channel is similar to the BR/EDR adapted piconet channel in that the set of PHY channels used can be modified to avoid interference. The set of used channels in the channel map is established by the master during connection setup. While in a connection the master can change the channel map when necessary to avoid new interferers. There are 37 LE piconet channels. The master can reduce this number through the channel map indicating the used channels. When the hopping pattern hits Source: CSv4.0, Vol. 1, p. 55.
15[G]. wherein at each hop in the hopping sequence, only one communications channel is used for communications between a pair of participants;	For each transmission/reception event, a single channel is used for communication between participants. Each of their transceivers must be tuned to the same RF channel at the same time.

	As specified in Part A, Section 2, 40 RF Channels are defined in the 2.4GHz ISM band. These RF Channels are allocated into two LE physical channels: advertising and data. The advertising physical channel uses three RF channels for discovering devices, initiating a connection and broadcasting data. The data physical channel uses up to 37 (see Section 4.5.8) RF channels for communication between connected devices. Each of these RF Channels is allocated a unique channel index (see Section 1.4.1). Two devices that wish to communicate use a shared physical channel. To achieve this, their transceivers must be tuned to the same RF Channel at the same time. Source: CSv4.0, Vol. 6, p. 34. In LE the hop index and channel map are used to identify a physical channel. The physical link is identified by the access address in the LE packet. Source: Source: CSv4.0, Vol. 1, p. 58.
15[H]. wherein the first identification data is provided to the participant over one communications channel of the plurality of communications channels based on the hopping sequence according to the frequency hopping protocol;	The identification data such as that in the CONNECT_REQ PDU is transmitted to slave devices over a single channel based on the same hopping sequence according to the frequency hopping protocol as other communication with devices in the piconet. As specified in Part A, Section 2, 40 RF Channels are defined in the 2.4GHz ISM band. These RF Channels are allocated into two LE physical channels: advertising and data. The advertising physical channel uses three RF channels for discovering devices, initiating a connection and broadcasting data. The data physical channel uses up to 37 (see Section 4.5.8) RF channels for communication between connected devices. Each of these RF Channels is allocated a unique channel index (see Section 1.4.1). Two devices that wish to communicate use a shared physical channel. To achieve this, their transceivers must be tuned to the same RF Channel at the same time.

	Source: CSv4.0, Vol. 6, p. 34.
15[I]. determining, based on second performance data that indicates performance of the first set of two or more communications channels at a second time that is later than the first time, a number of communications channels from the first set of two or more communications channels that satisfy at least a second performance criterion; and	The Accused Devices monitor and classify channels on an ongoing basis and/or according to a schedule. • The ChM field shall contain the channel map indicating *Used* and *Unused* data channels. Every channel is represented with a bit positioned as per the data channel index as defined in Section 1.4.1. The LSB represents data channel index 0 and the bit in position 36 represents data channel index 36. A bit value of '0' indicates that the channel is *Unused*. A bit value of '1' indicates that the channel is *Used*. The bits in positions 37, 38 and 39 are Reserved for Future Use. Note: When mapping from RF Channels to data channel index, care should be taken to remember that there is a gap where the second advertising channel is placed. • The Hop field shall be set to indicate the *hopIncrement* used in the data channel selection algorithm as defined in Section 4.5.8.2. It shall have a random value in the range of 5 to 16. Source: CSv4.0, Vol. 6, p. 43. *4.5.8.1 Channel Classification* The master's Link Layer shall classify data channels into *used channels* (used for the connection) and *unused channels* (not used for the connection). This is called the channel map. The minimum number of used channels shall be 2. The Host may provide channel classification information to the Link Layer. The Link Layer may use the information provided by the Host. The slave shall receive the channel map from the master in the CONNECT_REQ PDU. If the master changes the channel map it shall notify the slave as specified in Section 5.1.2. Source: CSv4.0, Vol. 6, p. 74. The master device periodically updates the set of used and unused channels based on performance measurements and evaluations subsequent to the creation and transmission of the first channel map. The

<table>
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update may be limited to the initial set of used channels in the first channel map, or it may include all 37 channels in the available band, including those in the first channel map as well as channels marked unused or unknown in that map.

6.3 CHANNEL MAP UPDATE

The Controller of the master may receive some channel classification data from the Host and then perform the Channel Update Link Layer Control Procedure (see Figure 6.3).

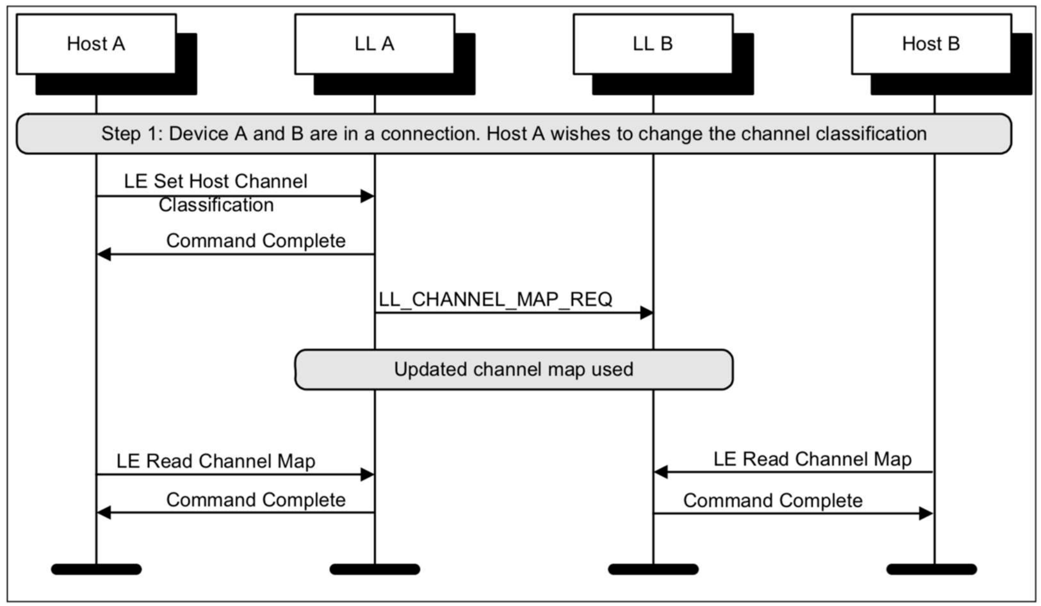
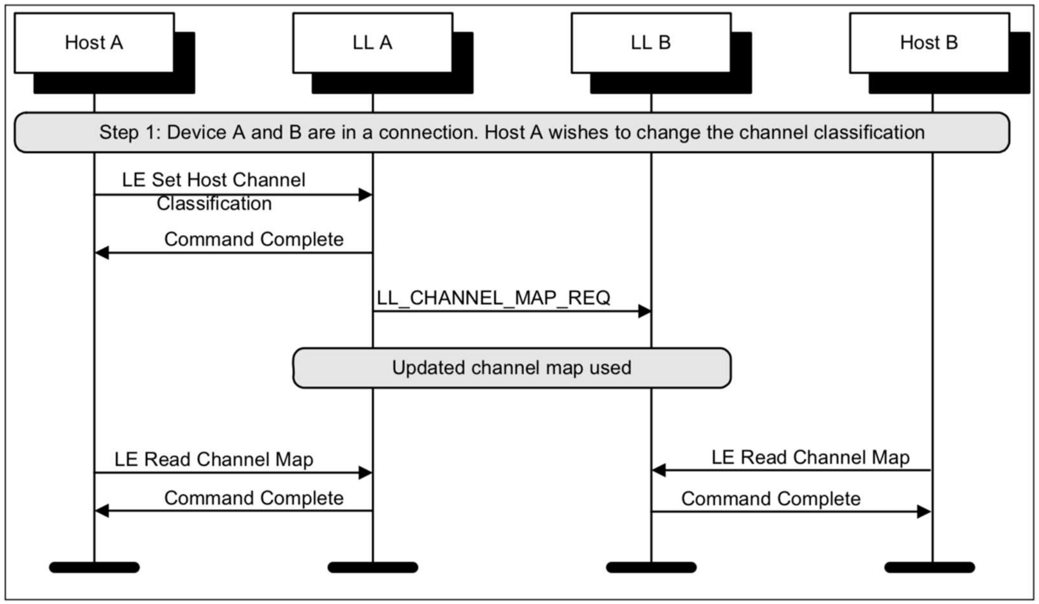


Figure 6.3: Channel Map Update

Source: CSv4.0, Vol. 6, pp. 111.
</td>
</tr>
<tr>
<td>15[J]. if the number of communications channels from the first set of two or</td>
<td>The adapted piconet uses at least 2 channels, and the Accused Devices may place further restrictions on the requirements for a channel map.</td>
</tr>
</table>

more communications channels is less than a specified number, then:	*4.5.8.1 Channel Classification* The master's Link Layer shall classify data channels into *used channels* (used for the connection) and *unused channels* (not used for the connection). This is called the channel map. The minimum number of used channels shall be 2. The Host may provide channel classification information to the Link Layer. The Link Layer may use the information provided by the Host. The slave shall receive the channel map from the master in the CONNECT_REQ PDU. If the master changes the channel map it shall notify the slave as specified in Section 5.1.2. Source: CSv4.0, Vol. 6, p. 74.
15[K]. selecting, based on third performance data that indicates performance of the plurality of communications channels at a third time that is at or later than the second time and at least a third performance criterion, a second set of two or more communications channels from the plurality of communications channels;	The Accused Devices monitor and classify channels on an ongoing basis and/or according to a schedule. • The ChM field shall contain the channel map indicating *Used* and *Unused* data channels. Every channel is represented with a bit positioned as per the data channel index as defined in Section 1.4.1. The LSB represents data channel index 0 and the bit in position 36 represents data channel index 36. A bit value of '0' indicates that the channel is *Unused*. A bit value of '1' indicates that the channel is *Used*. The bits in positions 37, 38 and 39 are Reserved for Future Use. Note: When mapping from RF Channels to data channel index, care should be taken to remember that there is a gap where the second advertising channel is placed. • The Hop field shall be set to indicate the *hopIncrement* used in the data channel selection algorithm as defined in Section 4.5.8.2. It shall have a random value in the range of 5 to 16. Source: CSv4.0, Vol. 6, p. 43.

	4.5.8.1 Channel Classification The master's Link Layer shall classify data channels into *used channels* (used for the connection) and *unused channels* (not used for the connection). This is called the channel map. The minimum number of used channels shall be 2. The Host may provide channel classification information to the Link Layer. The Link Layer may use the information provided by the Host. The slave shall receive the channel map from the master in the CONNECT_REQ PDU. If the master changes the channel map it shall notify the slave as specified in Section 5.1.2. Source: CSv4.0, Vol. 6, p. 74. The master device periodically updates the set of used and unused channels based on performance measurements and evaluations subsequent to the creation and transmission of the first channel map. The update may be limited to the initial set of used channels in the first channel map, or it may include all 37 channels in the available band, including those in the first channel map as well as channels marked unused or unknown in that map.

	6.3 CHANNEL MAP UPDATE The Controller of the master may receive some channel classification data from the Host and then perform the Channel Update Link Layer Control Procedure (see Figure 6.3).  *Figure 6.3: Channel Map Update* Source: CSv4.0, Vol. 6, pp. 111. When the Accused Device determines that—at a third time and using a third performance criterion—a second set of channels should be used for communication in the piconet, it prepares a new channel map from this set. This occurs, for example, when the second performance criterion evaluation results in a channel map that would contain fewer than two used channels, or would violate another of the Accused Device's threshold requirements for the number of used channels.
15[L]. generating second	The Accused Devices generate second identification data that describe the new channel map to be used for communication in a manner similar to that described above for the initial identification data.

identification data that identifies the second set of two or more communications channels;	After entering the Connection State, the master can update the channel map by sending an LL_CHANNEL_MAP_REQ PDU to slaves. This packet data contains a new channel map with the associated indexing and starting point as described previously. **5.1.2 Channel Map Update Procedure** The Link Layer parameter for channel map (*channelMap*) may be updated after entering the Connection State. The master can update the channel map by sending an LL_CHANNEL_MAP_REQ PDU. The slave shall not send this PDU. The Instant field of the LL_CHANNEL_MAP_REQ PDU shall be used to indicate the *connEventCount* when the $channelMap_{NEW}$ shall be applied; this is known as the instant. The master should allow a minimum of 6 connection events that the slave will be listening for before the instant occurs. Source: CSv4.0, Vol. 6, p. 80. A sample channel map update and sequence diagram are shown below. In the cited example, the number 0x1FFFFFF7FF is hexadecimal notation for the binary number 1111111111111111111111111011111111111. This is a zero-indexed set of the classifications of all 37 available channels. Each except channel 11 is classified as used (bit 1). Channel 11 is classified as unused (bit 0).

	For example: At connection set-up: - initial *channelMap*$_{OLD}$: 0x1FFFFFFFFF (i.e., all channels enabled) - initial *hopIncrement*: 10 (decimal) An LL_CHANNEL_MAP_REQ PDU with the following parameters is then issued: - Instant: 100 (decimal). Assume that no connection event count wrap-around occurred since the start of the connection. - *channelMap*$_{NEW}$: 0x1FFFFFF7FF (i.e. all channels enabled except channel 11) Source: CSv4.0, Vol. 6, p. 81.

6.3 CHANNEL MAP UPDATE

The Controller of the master may receive some channel classification data from the Host and then perform the Channel Update Link Layer Control Procedure (see Figure 6.3).

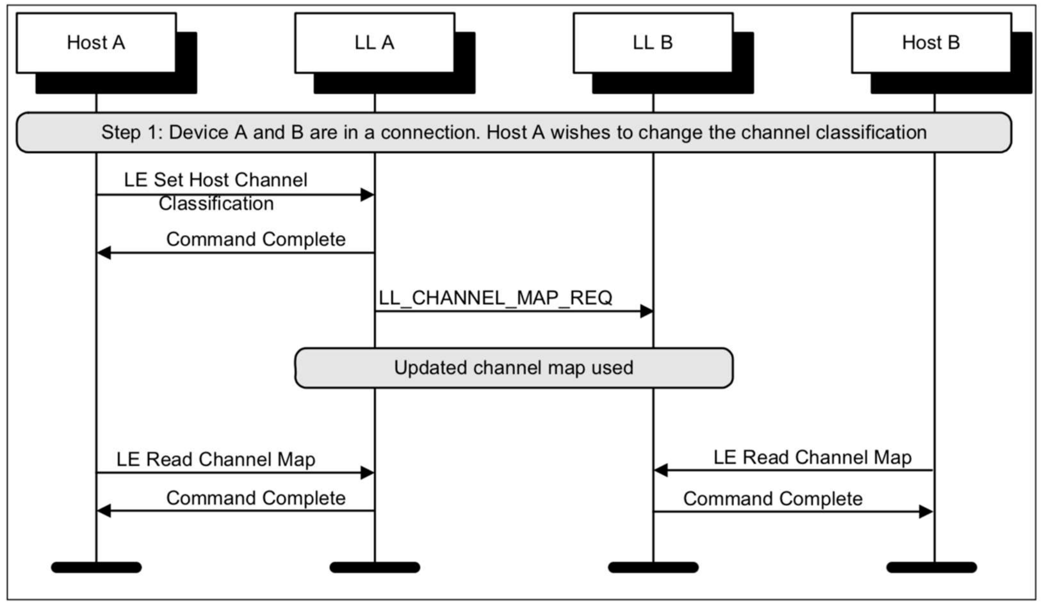


Figure 6.3: Channel Map Update

Source: CSv4.0, Vol. 6, pp. 111.

	The adaptive frequency-hopping updates are sent in a channel map request packet LL_CHANNEL_MAP_REQ. This is sent from the master to the slave and includes only the following two parameters: • New channel map • Instant The instant is the same concept as the instant used in the connection update. It determines a point in time that the new channel map will be used. At the instant, and afterward, the new channel map is used for all connection events in the future at least until the next time the channel map is updated. The channel map is a 37-bit field that has one bit for each data channel. If a given channel's bit is set to one, the channel is considered good and will be used; if a given channel's bit is set to zero, the channel is considered bad and will not be used. Source: Heydon, Robin, <u>Bluetooth Low Energy, The Developer's Handbook</u> 111 (2013). • The ChM field shall contain the channel map indicating *Used* and *Unused* data channels. Every channel is represented with a bit positioned as per the data channel index as defined in Section 1.4.1. The LSB represents data channel index 0 and the bit in position 36 represents data channel index 36. A bit value of '0' indicates that the channel is *Unused*. A bit value of '1' indicates that the channel is *Used*. The bits in positions 37, 38 and 39 are Reserved for Future Use. Note: When mapping from RF Channels to data channel index, care should be taken to remember that there is a gap where the second advertising channel is placed. • The Hop field shall be set to indicate the *hopIncrement* used in the data channel selection algorithm as defined in Section 4.5.8.2. It shall have a random value in the range of 5 to 16. Source: CSv4.0, Vol. 6, p. 43.
15[M]. providing the second	The new channel map identification data is provided from the master device to all slave devices in the piconet.

identification data to the participant over one communications channel of the plurality of communications channels based on the hopping sequence according to the frequency hopping protocol; and	**5.1.2 Channel Map Update Procedure** The Link Layer parameter for channel map (*channelMap*) may be updated after entering the Connection State. The master can update the channel map by sending an LL_CHANNEL_MAP_REQ PDU. The slave shall not send this PDU. The Instant field of the LL_CHANNEL_MAP_REQ PDU shall be used to indicate the *connEventCount* when the $channelMap_{NEW}$ shall be applied; this is known as the instant. The master should allow a minimum of 6 connection events that the slave will be listening for before the instant occurs. Source: CSv4.0, Vol. 6, p. 80. A sample channel map update and sequence diagram are shown below. In the cited example, the number 0x1FFFFFF7FF is hexadecimal notation for the binary number 1111111111111111111111111011111111111. This is a zero-indexed set of the classifications of all 37 available channels. Each except channel 11 is classified as used (bit 1). Channel 11 is classified as unused (bit 0). For example: At connection set-up: - initial $channelMap_{OLD}$: 0x1FFFFFFFFF (i.e., all channels enabled) - initial *hopIncrement*: 10 (decimal) An LL_CHANNEL_MAP_REQ PDU with the following parameters is then issued: - Instant: 100 (decimal). Assume that no connection event count wrap-around occurred since the start of the connection. - $channelMap_{NEW}$: 0x1FFFFFF7FF (i.e. all channels enabled except channel 11)

Source: CSv4.0, Vol. 6, p. 81.

6.3 CHANNEL MAP UPDATE

The Controller of the master may receive some channel classification data from the Host and then perform the Channel Update Link Layer Control Procedure (see Figure 6.3).

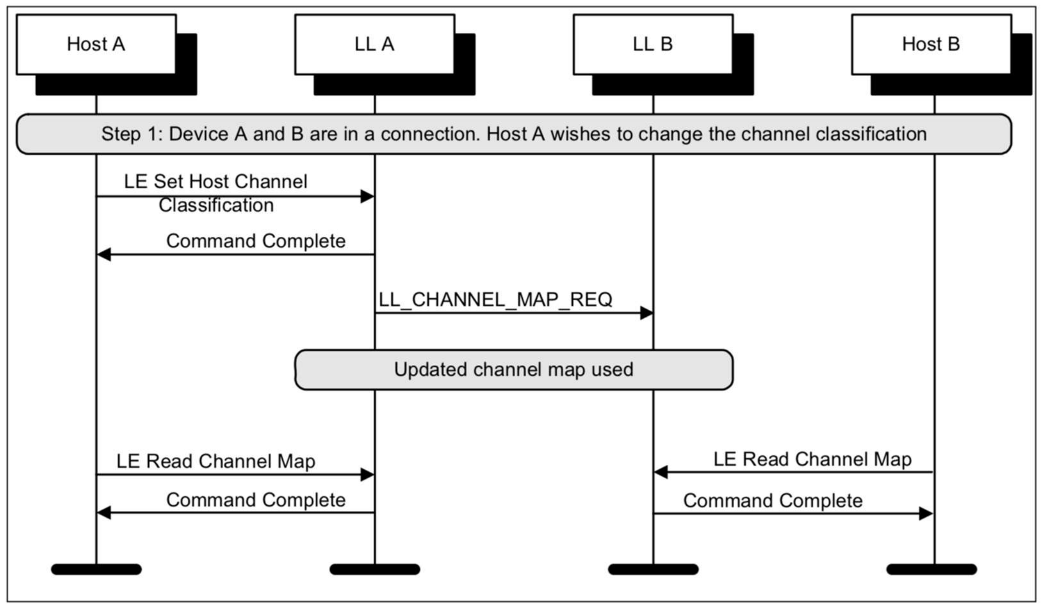


Figure 6.3: Channel Map Update

Source: CSv4.0, Vol. 6, pp. 111.

	The adaptive frequency-hopping updates are sent in a channel map request packet LL_CHANNEL_MAP_REQ. This is sent from the master to the slave and includes only the following two parameters: • New channel map • Instant The instant is the same concept as the instant used in the connection update. It determines a point in time that the new channel map will be used. At the instant, and afterward, the new channel map is used for all connection events in the future at least until the next time the channel map is updated. The channel map is a 37-bit field that has one bit for each data channel. If a given channel's bit is set to one, the channel is considered good and will be used; if a given channel's bit is set to zero, the channel is considered bad and will not be used. Source: Heydon, Robin, Bluetooth Low Energy, The Developer's Handbook 111 (2013). • The ChM field shall contain the channel map indicating *Used* and *Unused* data channels. Every channel is represented with a bit positioned as per the data channel index as defined in Section 1.4.1. The LSB represents data channel index 0 and the bit in position 36 represents data channel index 36. A bit value of '0' indicates that the channel is *Unused*. A bit value of '1' indicates that the channel is *Used*. The bits in positions 37, 38 and 39 are Reserved for Future Use. Note: When mapping from RF Channels to data channel index, care should be taken to remember that there is a gap where the second advertising channel is placed. • The Hop field shall be set to indicate the *hopIncrement* used in the data channel selection algorithm as defined in Section 4.5.8.2. It shall have a random value in the range of 5 to 16. Source: CSv4.0, Vol. 6, p. 43.
15[N].	When the new channel map takes effect, the Accused Devices communicate with other devices in the piconet

communicating with the participant over the second set of two or more communications channels.	over the channels in that map. Devices in a piconet use a specific frequency hopping pattern, which is algorithmically determined by a field contained in the connection request sent by an initiating device. The initiating device provides the synchronization reference known as a hop interval. The hopping pattern used in LE is a pseudo-random ordering of the 37 frequencies in the ISM band. The hopping pattern can be adapted to exclude a portion of the frequencies that are used by interfering devices. The adaptive hopping technique improves Bluetooth co-existence with Source: CSv4.0, Vol. 1, p. 21. The LE piconet channel is similar to the BR/EDR adapted piconet channel in that the set of PHY channels used can be modified to avoid interference. The set of used channels in the channel map is established by the master during connection setup. While in a connection the master can change the channel map when necessary to avoid new interferers. There are 37 LE piconet channels. The master can reduce this number through the channel map indicating the used channels. When the hopping pattern hits Source: CSv4.0, Vol. 1, p. 55. When unused channels are selected as candidate channels by the hop selection kernel, they are remapped to used channels.

The complete procedure is as shown in Figure 4.14.

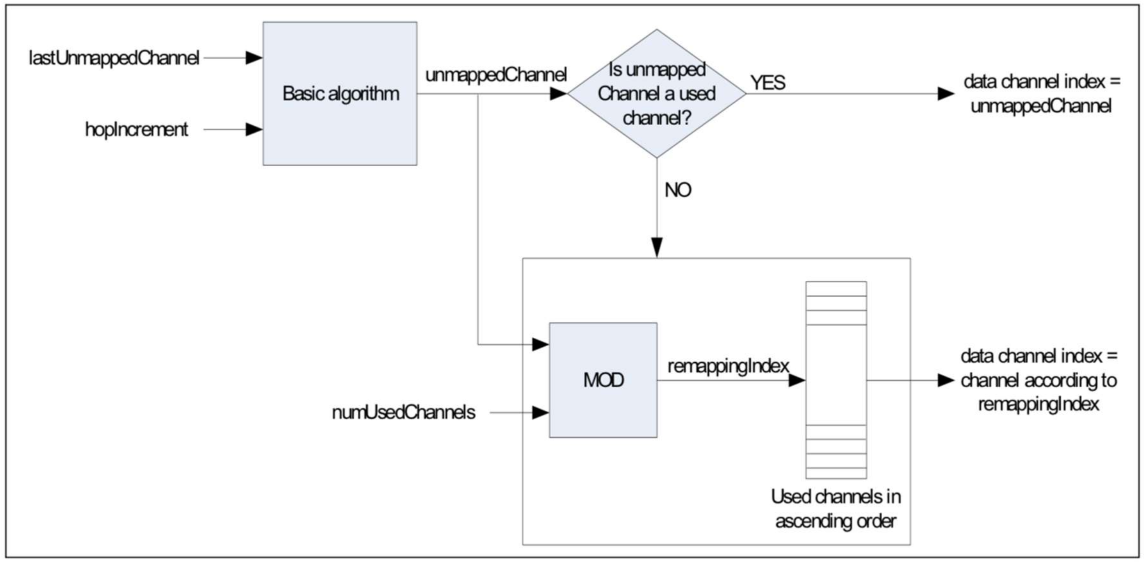


Figure 4.14: Block diagram of data channel selection algorithm

Source: CSv4.0, Vol. 6, p. 75.

	<u>*4.5.8.2 Channel Selection*</u> The channel selection algorithm consists of two stages: calculation of the unmapped channel index followed by mapping this index to a data channel index from the set of *used channels*. The *unmappedChannel* and *lastUnmappedChannel* are the unmapped channel indices of two consecutive connection events. The *unmappedChannel* is the unmapped channel index for the current connection event. The *lastUnmappedChannel* is the unmapped channel index of the previous connection event. The *lastUnmappedChannel* shall be '0' for the first connection event of a connection. At the start of a connection event, *unmappedChannel* shall be calculated using the following basic algorithm: *unmappedChannel* = (*lastUnmappedChannel* + *hopIncrement*) mod 37 When a connection event closes, the *lastUnmappedChannel* shall be set to the value of the *unmappedChannel*. If the *unmappedChannel* is a *used channel* according to the channel map, the channel selection algorithm shall use the *unmappedChannel* as the data channel index for the connection event. If the *unmappedChannel* is an *unused channel* according to the channel map, the *unmappedChannel* shall be re-mapped to one of the used channels in the channel map using the following algorithm: *remappingIndex* = *unmappedChannel* mod *numUsedChannels* Source: CSv4.0, Vol. 6, p. 74.

	where *numUsedChannels* is the number of used channels in the channel map. A remapping table is built that contains all the *used channels* in ascending order, indexed from zero. The *remappingIndex* is then used to select the data channel index for the connection event from the remapping table. Source: CSv4.0, Vol. 6, p. 75. Adaptive frequency hopping makes it possible for a given packet to be remapped from a known bad channel to a known good channel so that the interference from other devices is reduced. To do this, a channel map of good and bad channels is kept in both devices. If the channel that would have been chosen by using Equation 7-3 is a good channel, then that channel is used; if the channel that would have been chosen is a bad channel, then it is remapped onto the set of good channels, as depicted in Figure 7–15. A minimum of two data channels must be marked as good by a master. Suppose, for example, that a Bluetooth low energy device is in the same area as a Wi-Fi channel 1 access point that is streaming data to another Wi-Fi device. The Bluetooth low energy device would mark Link Layer data channels 0 to 8 as bad channels. This means that when the two devices are communicating, they would cycle through the channels and remap these channels to a set of good channels, as shown in Table 7–4 and Figure 7–16. Source: Heydon, Robin, Bluetooth Low Energy, The Developer's Handbook 88 (2013).

Table 7–4 An Example of Adaptive Frequency Channel Remapping

Original Channel	Good/Bad	Remapped Channel
0	Bad	9
13	Good	13
26	Good	26
2	Bad	11
15	Good	15
28	Good	28
4	Bad	13
17	Good	17
30	Good	30
6	Bad	15
19	Good	19
32	Good	32
8	Bad	17

Source: Heydon, Robin, Bluetooth Low Energy, The Developer's Handbook 89 (2013).

Exhibit 6. **Representative claim chart demonstrating infringement by by Curtis International Ltd.'s Bluetooth Low Energy Products**

U.S. Patent No. 9,883,520 v. Curtis International Ltd.'s Bluetooth Low Energy Products

Overview

Plaintiff accuses the provision, use, and operation of Curtis International Ltd.'s (“Defendant”) Bluetooth Low Energy Products of directly infringing U.S. Patent No. 9,883,520 (the “'520 Patent”). The term “Accused Devices” means Defendant's Bluetooth Low Energy Products and all associated interfaces, computer hardware, software and digital content, which includes but is not necessarily limited to the non-limiting example list of products included in *Exhibit 2*.

Plaintiff further accuses Defendant of indirectly infringing the '520 Patent through providing, authorizing and instructing regarding the Accused Devices to others, including its customers. Installing or activating the Accused Devices and the operation thereof directly infringe the asserted claims. Defendant intends to cause infringement by its customers and users. Defendant instructs users to use the Accused Devices in an infringing manner. Defendant enacts contractual protections requiring that the Accused Devices be used in a manner intended by Defendant. Defendant further instructs users to configure and operate the Accused Devices in an infringing manner. Defendant also provides support services for the Accused Devices, including providing instructions, guides, online materials and technical support.

The asserted claims include elements that are implemented, at least in part, by proprietary electronics and software in the Accused Devices. The precise source code, designs, data structures, processes, and algorithms used in them are held secret, at least in part, and are not publicly available in their entirety. An analysis of Defendant's documentation and/or source code may be necessary to fully and accurately describe all infringing features and functionality of the Accused Devices and, accordingly, Plaintiff reserves the right to supplement these contentions once such information is made available to Plaintiff. Furthermore, Plaintiff reserves the right to revise these contentions, including as discovery in the case progresses, in view of the Court's final claim construction in this action and in connection with the provision of its expert reports.

Claim 1	Infringement Contention
1[A]. A wireless communications device configured to:	The Accused Devices are wireless communications devices that certify compliance with the Bluetooth ("BT") Core Specification ("CS") Version 4.0 ("CSv4.0") or higher. CSv4.0 is available for download at: https://www.bluetooth.org/docman/handlers/downloaddoc.ashx?doc_id=229737. All Bluetooth Core Specifications are available at: https://www.bluetooth.com/specifications/bluetooth-core-specification. The Accused Devices may function in either master or slave roles in a Bluetooth Low Energy ("BLE") piconet, as those terms are defined in CS.
1[B]. send packet data to another wireless communications device in a wireless communications network, the packet data specifying a subset of communications channels used for frequency hopping communications of a set of communications channels in a frequency band, the packet data further comprising timing information indicating when to begin using the subset of communications channels for	The Accused Devices send packet data to other wireless devices with BT capabilities. Bluetooth Low Energy (LE) devices operate in the unlicensed 2.4 GHz ISM (Industrial Scientific Medical) band. A frequency hopping transceiver is used to combat interference and fading. Source: CSv4.0, Vol. 6, p. 14. **1.2 OVERVIEW OF BLUETOOTH LOW ENERGY OPERATION** Like the BR/EDR radio, the LE radio operates in the unlicensed 2.4 GHz ISM band. The LE system employs a frequency hopping transceiver to combat interference and fading and provides many FHSS carriers. LE radio operation uses a shaped, binary frequency modulation to minimize transceiver complexity. The symbol rate is 1 Megasymbol per second (Ms/s) supporting the bit rate of 1 Megabit per second (Mb/s). LE employs two multiple access schemes: Frequency division multiple access (FDMA) and time division multiple access (TDMA). Forty (40) physical channels, separated by 2 MHz, are used in the FDMA scheme. Three (3) are used as advertising channels and 37 are used as data channels. A TDMA based polling scheme is used in which one device transmits a packet at a predetermined time and a corresponding device responds with a packet after a predetermined interval. Source: CSv4.0, Vol. 1, p. 20.

frequency hopping communications;	As specified in Part A, Section 2, 40 RF Channels are defined in the 2.4GHz ISM band. These RF Channels are allocated into two LE physical channels: advertising and data. The advertising physical channel uses three RF channels for discovering devices, initiating a connection and broadcasting data. The data physical channel uses up to 37 (see Section 4.5.8) RF channels for communication between connected devices. Each of these RF Channels is allocated a unique channel index (see Section 1.4.1). Two devices that wish to communicate use a shared physical channel. To achieve this, their transceivers must be tuned to the same RF Channel at the same time. Source: CSv4.0, Vol. 6, p. 34. Communication between devices is in the form of packets. For example, the format of relevant Link Layer packets is shown below.

2.1 PACKET FORMAT

The Link Layer has only one packet format used for both advertising channel packets and data channel packets.

The packet format is shown in Figure 2.1. Each packet consists of four fields: the preamble, the Access Address, the PDU, and the CRC.

LSB MSB

Preamble (1 octet)	Access Address (4 octets)	PDU (2 to 39 octets)	CRC (3 octets)

Figure 2.1: Link Layer packet format

The preamble is 1 octet and the Access Address is 4 octets. The PDU range is from 2 to a maximum of 39 octets. The CRC is 3 octets.

The Preamble is transmitted first, followed by the Access Address, followed by the PDU followed by the CRC.

Source: CSv4.0, Vol. 6, pp. 36.

The Link Layer specification of the BT LE Link Layer governs communication between devices in a piconet. Packets in the Link Layer specification are Little Endian, with the least significant bit in the leftmost position. Examples herein from the specification should be interpreted to comply with this format.

1.2 BIT ORDERING

The bit ordering when defining fields within the packet or Protocol Data Unit (PDU) in the Link Layer specification follows the Little Endian format. The following rules apply:

- The Least Significant Bit (LSB) corresponds to b_0
- The LSB is the first bit sent over the air
- In illustrations, the LSB is shown on the left side

Furthermore, data fields defined in the Link Layer, such as the PDU header fields, shall be transmitted with the LSB first. For instance, a 3-bit parameter *X=3* is sent as:

$b_0b_1b_2 = 110$

Source: CSv4.0, Vol. 6, p. 32.

Connection

A grouping of two or more devices for communication is known as a piconet. In order to establish a piconet, an initiator device responds to an advertiser device's broadcast of connectable advertising events. The advertiser receives and accepts the initiator's request for connection, and a piconet comprising the two devices is formed. The initiator becomes the master device, and the advertiser becomes the slave device.

	Devices that transmit advertising packets on the advertising PHY channels are referred to as **advertisers**. Devices that receive advertising on the advertising channels without the intention to connect to the advertising device are referred to as **scanners**. Transmissions on the advertising PHY channels occur in advertising events. At the start of each advertising event, the advertiser sends an advertising packet corresponding to the advertising event type. Depending on the type of advertising packet, the scanner may make a request to the advertiser on the same advertising PHY channel which may be followed by a response from the advertiser on the same advertising PHY channel. The advertising PHY channel changes on the next advertising packet sent by the advertiser in the same advertising event. The advertiser may end the advertising event at any time during the event. The first advertising PHY channel is used at the start of the next advertising event. Source: CSv4.0, Vol. 1, p. 20. Devices that need to form a connection to another device listen for connectable advertising packets. Such devices are referred to as **initiators**. If the advertiser is using a connectable advertising event, an initiator may make a connection request using the same advertising PHY channel on which it received the connectable advertising packet. The advertising event is ended and connection events begin if the advertiser receives and accepts the request for a connection be initiated. Once a connection is established, the initiator becomes the **master** device in what is referred to as a **piconet** and the advertising device becomes the **slave** device. Connection events are used to send data packets between the master and slave devices. In connection events, channel hopping occurs at the start of each connection event. Within a connection event, the master and slave alternate sending data packets using the same data PHY channel. The master initiates the beginning of each connection event and can end each connection event at any time. Source: CSv4.0, Vol. 1, p. 21.

	The Link Layer in the Advertising State will be transmitting advertising channel packets and possibly listening to and responding to responses triggered by these advertising channel packets. A device in the Advertising State is known as an advertiser. The Advertising State can be entered from the Standby State. The Link Layer in the Scanning State will be listening for advertising channel packets from devices that are advertising. A device in the Scanning State is known as a scanner. The Scanning State can be entered from the Standby State. The Link Layer in the Initiating State will be listening for advertising channel packets from a specific device(s) and responding to these packets to initiate a connection with another device. A device in the Initiating State is known as an initiator. The Initiating State can be entered from the Standby State. The Connection State can be entered either from the Initiating State or the Advertising State. A device in the Connection State is known as being in a connection. Within the Connection State, two roles are defined: • Master Role • Slave Role Source: CSv4.0, Vol. 6, p. 31. **4.5 CONNECTION STATE** The Link Layer enters the Connection State when an initiator sends a CONNECT_REQ PDU to an advertiser or an advertiser receives a CONNECT_REQ PDU from an initiator. After entering the Connection State, the connection is considered to be created. The connection is not considered to be established at this point. A con- Source: CSv4.0, Vol. 6, p. 67.

	The structure of the CONNECT_REQ PDU, which initiates the formation of a piconet, is shown below.

2.3.3 Initiating PDUs

The following advertising channel PDU Type is called the initiating PDU:

- CONNECT_REQ

This PDU is sent by the Link Layer in the Initiating State and received by the Link Layer in the Advertising State.

2.3.3.1 CONNECT_REQ

The CONNECT_REQ PDU has the Payload as shown in Figure 2.10. TxAdd in the Flags field indicates whether the initiator's device address in the InitA field is public (TxAdd = 0) or random (TxAdd = 1). The RxAdd in the Flags field indicates whether the advertiser's device address in the AdvA field is public (RxAdd = 0) or random (RxAdd = 1).

Payload		
InitA (6 octets)	AdvA (6 octets)	LLData (22 octets)

Figure 2.10: CONNECT_REQ PDU payload

Source: CSv4.0, Vol. 6, p. 42.

The CONNECT_PDU packet contains an LLData field, the structure of which is shown below.

LLData									
AA (4 octets)	CRCInit (3 octets)	WinSize (1 octet)	WinOffset (2 octets)	Interval (2 octets)	Latency (2 octets)	Timeout (2 octets)	ChM (5 octets)	Hop (5 bits)	SCA (3 bits)

Figure 2.11: LLData field structure in CONNECT_REQ PDU's payload

Source: CSv4.0, Vol. 6, p. 43.

	The LLData field further contains several fields which are determinative of a frequency hopping pattern and associated timing to be used for communication by the piconet. This pattern is a specific ordering of data channels (by index position) in the available frequency band (37 RF channels). The ordered channel set may be may be adjusted by the master to exclude one or more channels in use by interfering devices. Devices in a piconet use a specific frequency hopping pattern, which is algorithmically determined by a field contained in the connection request sent by an initiating device. The initiating device provides the synchronization reference known as a hop interval. The hopping pattern used in LE is a pseudo-random ordering of the 37 frequencies in the ISM band. The hopping pattern can be adapted to exclude a portion of the frequencies that are used by interfering devices. The adaptive hopping technique improves Bluetooth co-existence with Source: CSv4.0, Vol. 1, p. 21. The LE piconet channel is similar to the BR/EDR adapted piconet channel in that the set of PHY channels used can be modified to avoid interference. The set of used channels in the channel map is established by the master during connection setup. While in a connection the master can change the channel map when necessary to avoid new interferers. There are 37 LE piconet channels. The master can reduce this number through the channel map indicating the used channels. When the hopping pattern hits Source: CSv4.0, Vol. 1, p. 55. A sample indexing of RF channels to data channel and advertising channel indices is shown below.

	Table 1.2 shows the mapping from RF Channel to Data Channel Index and Advertising Channel Index. It also shows the allocation of channel type to each RF Channel.

RF Channel	RF Center Frequency	Channel Type	Data Channel Index	Advertising Channel Index
0	2402 MHz	Advertising channel		37
1	2404 MHz	Data channel	0	
2	2406 MHz	Data channel	1	
...	...	Data channels	...	
11	2424 MHz	Data channel	10	
12	2426 MHz	Advertising channel		38
13	2428 MHz	Data channel	11	
14	2430 MHz	Data channel	12	
...	...	Data channels	...	
38	2478 MHz	Data channel	36	
39	2480 MHz	Advertising channel		39

Table 1.2: Mapping of RF Channel to Data Channel Index and Advertising Channel Index

Source: CSv4.0, Vol. 6, p. 35.

The LLData field contains ChM and Hop fields, which are described below. The ChM field contains an initial channel map, which specifies a subset of channels for frequency hopping communication. For example, channels are classified as used or unused, and are indexed in the data channel index. The Hop field contains an increment value used as input to the channel selection algorithm of the frequency hopping communication.

	• The ChM field shall contain the channel map indicating *Used* and *Unused* data channels. Every channel is represented with a bit positioned as per the data channel index as defined in Section 1.4.1. The LSB represents data channel index 0 and the bit in position 36 represents data channel index 36. A bit value of ‘0’ indicates that the channel is *Unused*. A bit value of ‘1’ indicates that the channel is *Used*. The bits in positions 37, 38 and 39 are Reserved for Future Use. Note: When mapping from RF Channels to data channel index, care should be taken to remember that there is a gap where the second advertising channel is placed. • The Hop field shall be set to indicate the *hopIncrement* used in the data channel selection algorithm as defined in Section 4.5.8.2. It shall have a random value in the range of 5 to 16. Source: CSv4.0, Vol. 6, p. 43. *4.5.8.1 Channel Classification* The master’s Link Layer shall classify data channels into *used channels* (used for the connection) and *unused channels* (not used for the connection). This is called the channel map. The minimum number of used channels shall be 2. The Host may provide channel classification information to the Link Layer. The Link Layer may use the information provided by the Host. The slave shall receive the channel map from the master in the CONNECT_REQ PDU. If the master changes the channel map it shall notify the slave as specified in Section 5.1.2. Source: CSv4.0, Vol. 6, p. 74. The packet data further comprises timing information in the form of the sent time of the packets, as well as the Interval and Latency fields in the LLData field which establish an anchor point and period that is used to determine the timing of subsequent packet transmissions according to the frequency hopping algorithm. Time is measured in the number of transmission slots or events.

	Given that Bluetooth low energy has no clock, the only way to determine an instant is to count connection events. Therefore, each connection event is counted, with zero being the first connection event in the link; the one that was transmitted in the first transmit window after the connection request. The instant, therefore, is the connection event count at which the new parameters will be used. The master should provide enough opportunity for the slave to receive this packet. Even at maximum latency, this should typically allow at least six attempts for the message to be sent by the master to the slave. If the slave latency is 500 milliseconds, then the instant would typically be placed at least 3 seconds in the future. Once the instant arrives, the slave listens for the transmit window, just like during connection creation. This allows the master to shift the timing of the slaves, both within the 1.25-millisecond slot but also at the gross level. This better allows the master device that is also a Bluetooth classic device to align its own Bluetooth low energy slaves to those of its other activities. Once this procedure is complete, a new connection interval, supervision timeout, and slave latency values are used. Source: Heydon, Robin, <u>Bluetooth Low Energy, The Developer's Handbook</u> 111 (2013).

	The LE piconet channel is characterized by a pseudo-random sequence of PHY channels and by three additional parameters provided by the master. The first is the channel map that indicates the set of PHY channels used in the piconet. The second is a pseudo random number used as an index into the complete set of PHY channels. The third is the timing of the first data packet sent by the master after the connection request. The channel is divided into connection events where each connection event corresponds to a PHY hop channel. Consecutive connection events correspond to different PHY hop channels. The first packet sent by the master after the connection establishment sets an anchor point for the timing of all future connection events. In a connection event the master transmits packets to a slave in the piconet and the slave may or may not respond with a packet of its own. Source: CSv4.0, Vol. 1, p. 55. On the LE piconet channel the master controls access to the channel. The master starts its transmission in a connection event that occurs at regular intervals. Packets transmitted by the master are aligned with the connection event start and define the piconet timing. Packets sent by the master may vary in length from 10 to 47 octets. Source: CSv4.0, Vol. 1, p. 55. • The Interval field shall be set to indicate the *connInterval* as defined in Section 4.5.1 in the following manner:*connInterval* = Interval * 1.25 ms. • The Latency field shall be set to indicate the *connSlaveLatency*value, as defined in Section 4.5.1 in the following manner: *connSlaveLatency* = Latency. Source: CSv4.0, Vol. 6, pp. 43.

> The first packet sent in the Connection State by the master determines the anchor point for the first connection event, and therefore the timings of all future connection events in this connection.
>
> The second connection event anchor point shall be *connInterval* after the first connection event anchor point. All the normal connection event transmission rules specified in Section 4.5.1 shall apply.

Source: CSv4.0, Vol. 6, pp. 70.

Update

The Accused Devices further implement a procedure for updating the subset of channels to be used for communication in an existing piconet. After entering the Connection State, the master can update the channel map by sending an LL_CHANNEL_MAP_REQ PDU to slaves. This packet data contains a new channel map with the associated indexing and starting point as described previously. It further includes an Instant field, which indicates when the new channel map shall take effect for communication within the piconet.

> **5.1.2 Channel Map Update Procedure**
>
> The Link Layer parameter for channel map (*channelMap*) may be updated after entering the Connection State. The master can update the channel map by sending an LL_CHANNEL_MAP_REQ PDU. The slave shall not send this PDU.
>
> The Instant field of the LL_CHANNEL_MAP_REQ PDU shall be used to indicate the *connEventCount* when the $channelMap_{NEW}$ shall be applied; this is known as the instant. The master should allow a minimum of 6 connection events that the slave will be listening for before the instant occurs.

Source: CSv4.0, Vol. 6, p. 80.

A sample channel map update and sequence diagram are shown below. In the cited example, the number 0x1FFFFFF7FF is hexadecimal notation for the binary number 1111111111111111111111111011111111111.

This is a zero-indexed set of the classifications of all 37 available channels. Each except channel 11 is classified as used (bit 1). Channel 11 is classified as unused (bit 0).

For example:

At connection set-up:

- initial $channelMap_{OLD}$: 0x1FFFFFFFFF (i.e., all channels enabled)
- initial *hopIncrement*: 10 (decimal)

An LL_CHANNEL_MAP_REQ PDU with the following parameters is then issued:

- Instant: 100 (decimal). Assume that no connection event count wrap-around occurred since the start of the connection.
- $channelMap_{NEW}$: 0x1FFFFFF7FF (i.e. all channels enabled except channel 11)

Source: CSv4.0, Vol. 6, p. 81.

6.3 CHANNEL MAP UPDATE

The Controller of the master may receive some channel classification data from the Host and then perform the Channel Update Link Layer Control Procedure (see Figure 6.3).

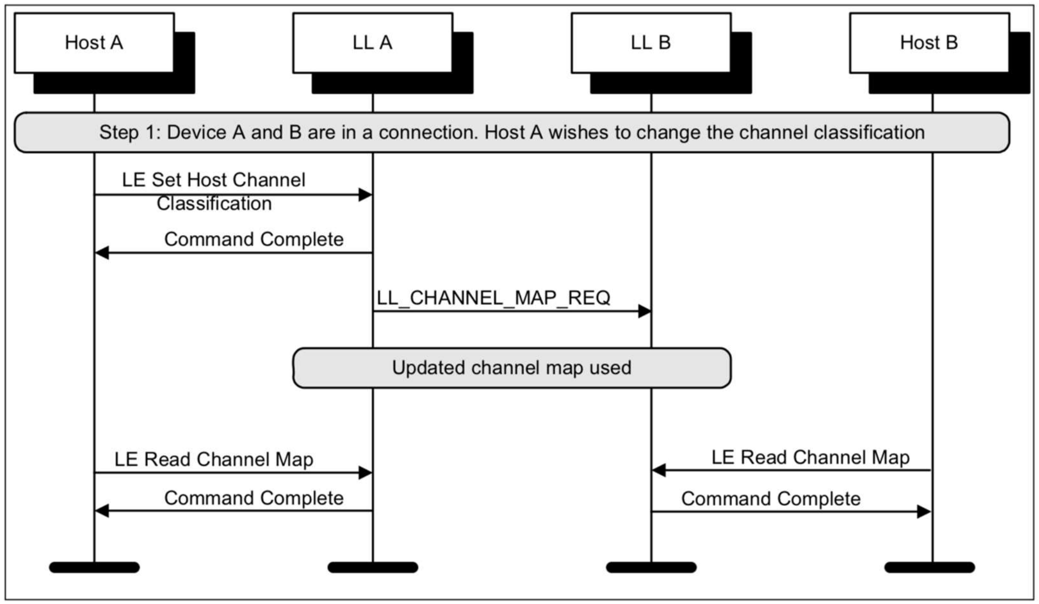
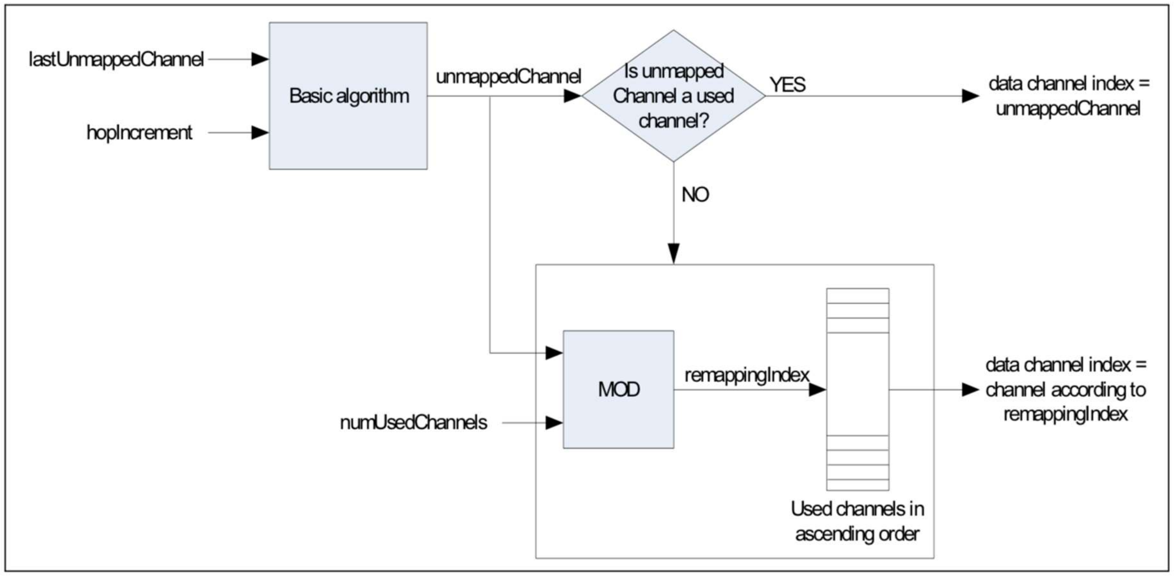


Figure 6.3: Channel Map Update

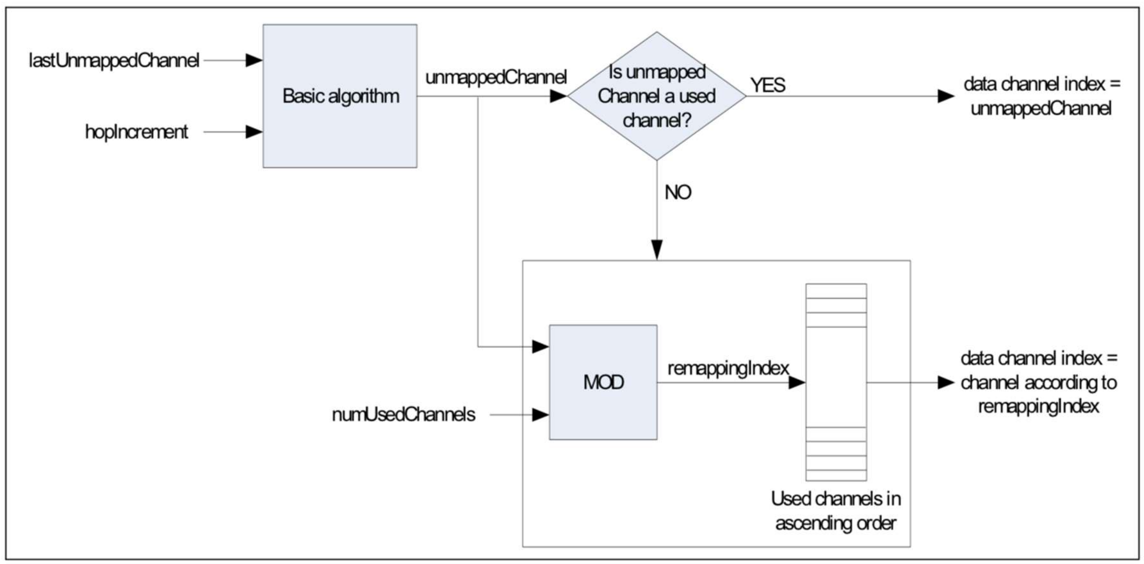
Source: CSv4.0, Vol. 6, pp. 111.

	The adaptive frequency-hopping updates are sent in a channel map request packet LL_CHANNEL_MAP_REQ. This is sent from the master to the slave and includes only the following two parameters: • New channel map • Instant The instant is the same concept as the instant used in the connection update. It determines a point in time that the new channel map will be used. At the instant, and afterward, the new channel map is used for all connection events in the future at least until the next time the channel map is updated. The channel map is a 37-bit field that has one bit for each data channel. If a given channel's bit is set to one, the channel is considered good and will be used; if a given channel's bit is set to zero, the channel is considered bad and will not be used. Source: Heydon, Robin, <u>Bluetooth Low Energy, The Developer's Handbook</u> 111 (2013).
1[C]. identify a communications channel from the set of communications channels;	When the Accused Devices need to communicate with another device in the piconet, as described above, a candidate channel from the available frequency band is identified. In LE the hop index and channel map are used to identify a physical channel. The physical link is identified by the access address in the LE packet. Source: Source: CSv4.0, Vol. 1, p. 58.

	There are 37 LE piconet channels. The master can reduce this number through the channel map indicating the used channels. When the hopping pattern hits Data Transport Architecture 30 June 2010 BLUETOOTH SPECIFICATION Version 4.0 [Vol 1] page 56 of 140 *Architecture* Bluetooth® an unused channel the unused channel is replaced with an alternate from the set of used channels. Source: CSv4.0, Vol. 1, pp. 55-56.
1[D]. use the identified communications channel for frequency hopping communications with the other wireless communications device at a time slot at or after the wireless communications device and the other wireless communications	If the identified channel is identified by the channel set as used and is the next usable channel according to the channel selection and hopping algorithms, the Accused Devices use it for communication with the slave device.

device begin using the subset of communications channels for frequency hopping communications, if the identified communications channel is used for frequency hopping communications; and	The complete procedure is as shown in Figure 4.14.  *Figure 4.14: Block diagram of data channel selection algorithm* Source: CSv4.0, Vol. 6, p. 75.

	4.5.8.2 Channel Selection The channel selection algorithm consists of two stages: calculation of the unmapped channel index followed by mapping this index to a data channel index from the set of *used channels*. The *unmappedChannel* and *lastUnmappedChannel* are the unmapped channel indices of two consecutive connection events. The *unmappedChannel* is the unmapped channel index for the current connection event. The *lastUnmappedChannel* is the unmapped channel index of the previous connection event. The *lastUnmappedChannel* shall be ‘0’ for the first connection event of a connection. At the start of a connection event, *unmappedChannel* shall be calculated using the following basic algorithm: *unmappedChannel* = (*lastUnmappedChannel* + *hopIncrement*) mod 37 When a connection event closes, the *lastUnmappedChannel* shall be set to the value of the *unmappedChannel*. If the *unmappedChannel* is a *used channel* according to the channel map, the channel selection algorithm shall use the *unmappedChannel* as the data channel index for the connection event. If the *unmappedChannel* is an *unused channel* according to the channel map, the *unmappedChannel* shall be re-mapped to one of the used channels in the channel map using the following algorithm: *remappingIndex* = *unmappedChannel* mod *numUsedChannels* Source: CSv4.0, Vol. 6, p. 74.

	where *numUsedChannels* is the number of used channels in the channel map. A remapping table is built that contains all the *used channels* in ascending order, indexed from zero. The *remappingIndex* is then used to select the data channel index for the connection event from the remapping table. Source: CSv4.0, Vol. 6, p. 75.
1[E]. use a communications channel in the subset of communications channels for frequency hopping communications with the other wireless communications device at the time slot, if the identified communications channel is not used for frequency hopping communications.	If the identified channel is *not* identified by the channel set as used, the Accused Devices does not use it and instead uses the next available used channel according to the channel selection, hopping, and remapping algorithms and procedures. The complete procedure is as shown in Figure 4.14.  *Figure 4.14: Block diagram of data channel selection algorithm* Source: CSv4.0, Vol. 6, p. 75.

	<u>*4.5.8.2 Channel Selection*</u> The channel selection algorithm consists of two stages: calculation of the unmapped channel index followed by mapping this index to a data channel index from the set of *used channels*. The *unmappedChannel* and *lastUnmappedChannel* are the unmapped channel indices of two consecutive connection events. The *unmappedChannel* is the unmapped channel index for the current connection event. The *lastUnmappedChannel* is the unmapped channel index of the previous connection event. The *lastUnmappedChannel* shall be '0' for the first connection event of a connection. At the start of a connection event, *unmappedChannel* shall be calculated using the following basic algorithm: *unmappedChannel* = (*lastUnmappedChannel* + *hopIncrement*) mod 37 When a connection event closes, the *lastUnmappedChannel* shall be set to the value of the *unmappedChannel*. If the *unmappedChannel* is a *used channel* according to the channel map, the channel selection algorithm shall use the *unmappedChannel* as the data channel index for the connection event. If the *unmappedChannel* is an *unused channel* according to the channel map, the *unmappedChannel* shall be re-mapped to one of the used channels in the channel map using the following algorithm: *remappingIndex* = *unmappedChannel* mod *numUsedChannels* Source: CSv4.0, Vol. 6, p. 74.

	where *numUsedChannels* is the number of used channels in the channel map. A remapping table is built that contains all the *used channels* in ascending order, indexed from zero. The *remappingIndex* is then used to select the data channel index for the connection event from the remapping table. Source: CSv4.0, Vol. 6, p. 75. Adaptive frequency hopping makes it possible for a given packet to be remapped from a known bad channel to a known good channel so that the interference from other devices is reduced. To do this, a channel map of good and bad channels is kept in both devices. If the channel that would have been chosen by using Equation 7-3 is a good channel, then that channel is used; if the channel that would have been chosen is a bad channel, then it is remapped onto the set of good channels, as depicted in Figure 7–15. A minimum of two data channels must be marked as good by a master. Suppose, for example, that a Bluetooth low energy device is in the same area as a Wi-Fi channel 1 access point that is streaming data to another Wi-Fi device. The Bluetooth low energy device would mark Link Layer data channels 0 to 8 as bad channels. This means that when the two devices are communicating, they would cycle through the channels and remap these channels to a set of good channels, as shown in Table 7–4 and Figure 7–16. Source: Heydon, Robin, Bluetooth Low Energy, The Developer's Handbook 88 (2013).

Table 7–4 An Example of Adaptive Frequency Channel Remapping

Original Channel	Good/Bad	Remapped Channel
0	Bad	9
13	Good	13
26	Good	26
2	Bad	11
15	Good	15
28	Good	28
4	Bad	13
17	Good	17
30	Good	30
6	Bad	15
19	Good	19
32	Good	32
8	Bad	17

Source: Heydon, Robin, Bluetooth Low Energy, The Developer's Handbook 89 (2013).